Chapter 8

Conservation Measures for Aquatic Habitat

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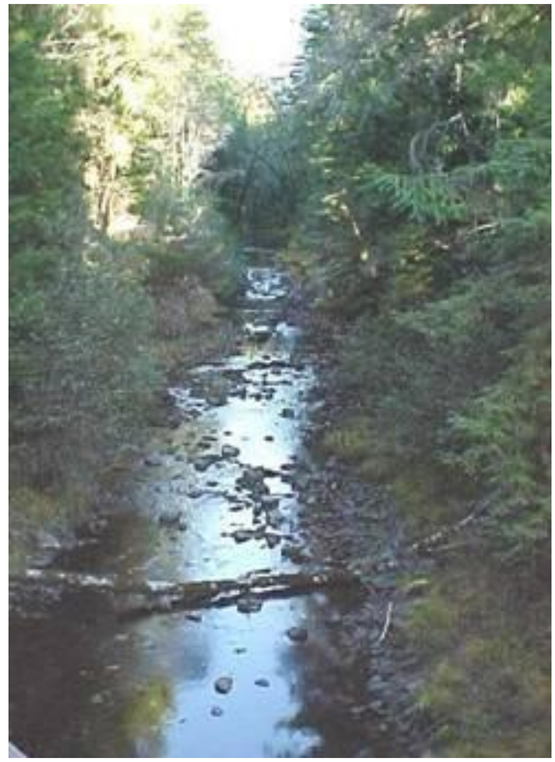
8 CONSERVATION MEASURES FOR AQUATIC HABITAT

8.1 Introduction



Chapter 8 addresses the conservation measures for aquatic habitat under the topics of riparian and wetland areas, sediment inputs, and hydrologic change. Each of these sub-sections includes overviews, goals and objectives, conservation measures, and rationales. Later, Chapter 10 provides conservation measures for covered fish and amphibian species within this aquatic habitat.

Quite simply, aquatic habitat is where aquatic species live, breed, and rear offspring. Natural habitat for anadromous salmonid species is within streams and rivers; for amphibian species, it is in streams, rivers, ponds, and wetlands—and partly in riparian and upland areas where amphibians sometimes forage. Through our HCP/NCCP, MRC will maintain and enhance aquatic habitat while protecting beneficial uses of water. Unquestionably, this is a challenge, because aquatic habitat is influenced by many environmental factors, such as rising or falling temperatures and sediment in streams.

In Chapter 3, we acknowledged that watershed analyses indicate that we need to improve environmental conditions on our land. Our most critical issues are managing riparian stands to recruit LWD for streams and reducing sediment input to streams from roads. In addition, we must increase stream shade in riparian areas and decrease sediment inputs from mass wasting and skid trails. Research on the effects of forest harvest on hydrologic change has also prompted us to consider new ways to minimize hydrologic change and its impacts to aquatic species. All of the conservation measures proposed in this chapter, therefore, reflect a good deal of corporate introspection.

8.2 Riparian and Wetland Areas

8.2.1 Overview

Riparian areas are zones of vegetation adjacent to a stream, river, lake, or wetland. They influence the adjacent water and are, in turn, influenced by it. Riparian areas form the link between terrestrial and aquatic environments, exerting a strong impact on the biological and physical processes that create and maintain aquatic habitat.

Riparian function is a measure of how well streamside vegetation can

- Recruit streamside trees for large woody debris (LWD).
- Shade streams with canopy.
- Moderate summer water temperatures.
- Sustain a cool micro-climate.
- Stabilize stream banks.

- Maintain channel form.
- Filter sediment adjacent to streams.
- Provide nutrient cycling, organic material, and hydraulic roughness for floodplains.
- Produce habitat for riparian obligate plants and animals.

Forest management can affect aquatic habitat by altering riparian function. Adverse conditions attributed to forest management include mass wasting, road erosion, and changes to watershed hydrology. In some cases, conservation measures that address riparian function also provide protection to aquatic habitat by reducing sediment and mitigating hydrologic change.

8.2.1.1 Defining basic terms and concepts

In this subsection, we provide definitions and illustrations of key terms that occur frequently in the conservation measures and rationale for riparian and wetland areas.

8.2.1.1.1 DBH and basal area

DEFINITION

DBH is the diameter of a tree at breast height or 4.5 ft above the ground; diameter is calculated from the circumference of a tree trunk.

Basal area (BA) is the circular area of a tree cross-section at dbh, i.e., $A = \pi r^2$ or $A = \pi(dbh/2)^2$.

Basal area per acre is the summation of the individual basal areas for all the trees within an acre.

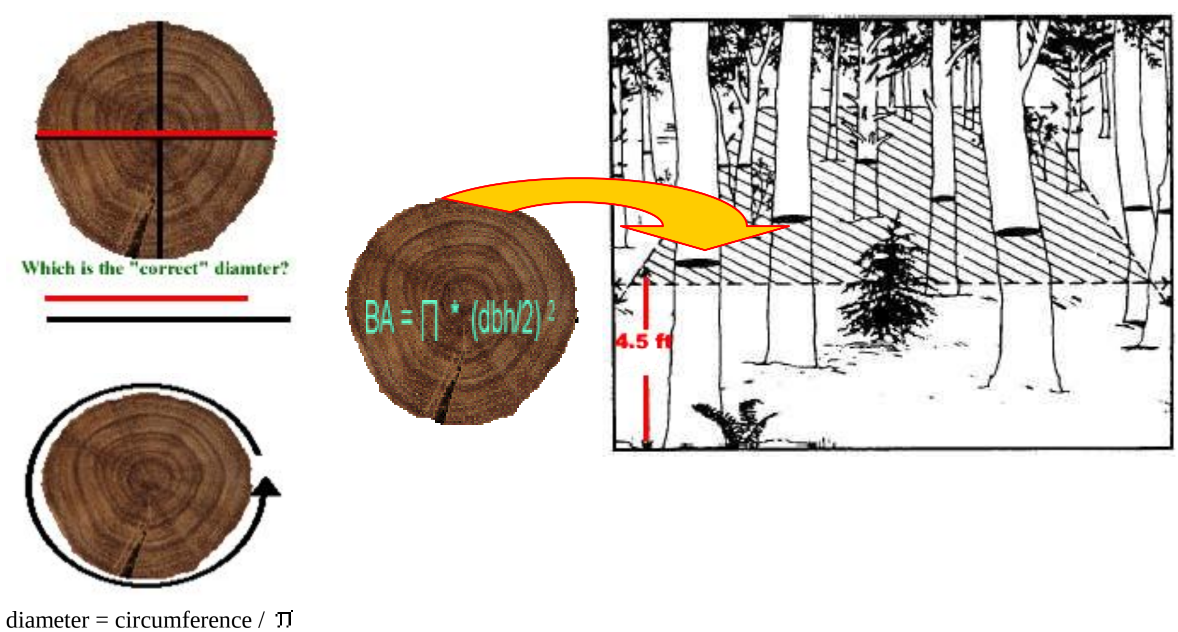


Figure 8-1 DBH and Basal Area[1]

[1] This figure was developed from illustrations of basal area in *Stewardship Notes*, Indiana Division of Forestry and of cross-sectional diameters from *The School of Resources, Environment, and Society*, Australian National University.

8.2.1.1.2 Watercourse classifications and AMZ

DEFINITION	**Aquatic Management Zone** (AMZ) is the strip along Class I, Class II, and Class III watercourses where MRC will manage riparian function.[2]

MRC classifies watercourses based on available information about presence of aquatic species and habitat characteristics. The categories shown in Table 8-1 are Class I, Class II, and Class III. Unlike the categories for Class I and Class III, MRC sub-divides Class II into large and small watercourses. In doing so, we hypothesize that drainage areas of at least 100 ac (i.e., Large Class II watercourses) support perennial surface water, whereas drainage areas less than 100 ac (i.e., Small Class II watercourses) do not. Moreover, we consider watersheds with perennial surface water to be important both for cold water inputs to larger watercourses and for habitat for cold water amphibians which require perennial water for larval development.

Table 8-1 Watercourse Definitions

Watercourse Classification	Definition
Class I	Fish always or seasonally present on-site. Includes habitat to sustain fish migration and spawning, as well as man-made lakes or ponds inhabited by stocked native fish. Also includes Class II streams that could be restored for fish habitat. Excludes man-made lakes or ponds inhabited only with non-native fish (modified from CCR 916.5 Table I, 2002[3]).
Large Class II	Watercourses with aquatic habitat for non-fish aquatic species (modified from CCR 916.5 Table I, 2002). Drainage area is at least 100 ac or surface flow is perennial during normal annual rainfall. MRC may adjust threshold acreage through adaptive management. MRC will treat watersheds with breeding coastal tailed frogs present as Large Class II regardless of the size of the watershed area.
Small Class II	Watercourses with aquatic habitat for non-fish aquatic species (modified from CCR 916.5 Table I, 2002). Drainage area is less than 100 ac; MRC may adjust this acreage through adaptive management (see Chapter 13, M§13.5.1.2-3).
Class III[4]	Watercourses with no aquatic habitat present. Shows capability of transporting sediment downstream to Class I and Class II waters under normal high water conditions and after timber operations (CCR 916.5 Table I, 2002).

[2] The Forest Practice Rules use the term Watercourse and Lake Protection Zone (WLPZ) to describe the riparian protection area.

[3] Modifications to these classifications are as follows: (a) Class I does not include domestic water sources, although MRC will protect domestic water sources per CCR 916.5; and (b) Class II watercourses include Small and Large Class II watercourses. The MRC distinction between Small and Large Class II watercourses is different from the classification in the Anadromous Salmonid Protection Rules adopted by the Board of Forestry in 2009.

[4] The Science Panel advised that MRC include soil pipes that can contribute sediment to a Class I or Class II watercourse in the definition of a Class III watercourse. Instead, MRC has developed conservation measures specific to soil pipes (C§8.2.3.2.6-1 through C§8.2.3.2.6-5).

Figure 8-2 depicts major stream classes in a watershed as well as other terms in this chapter, such as evapotranspiration, infiltration, and groundwater aquifer.

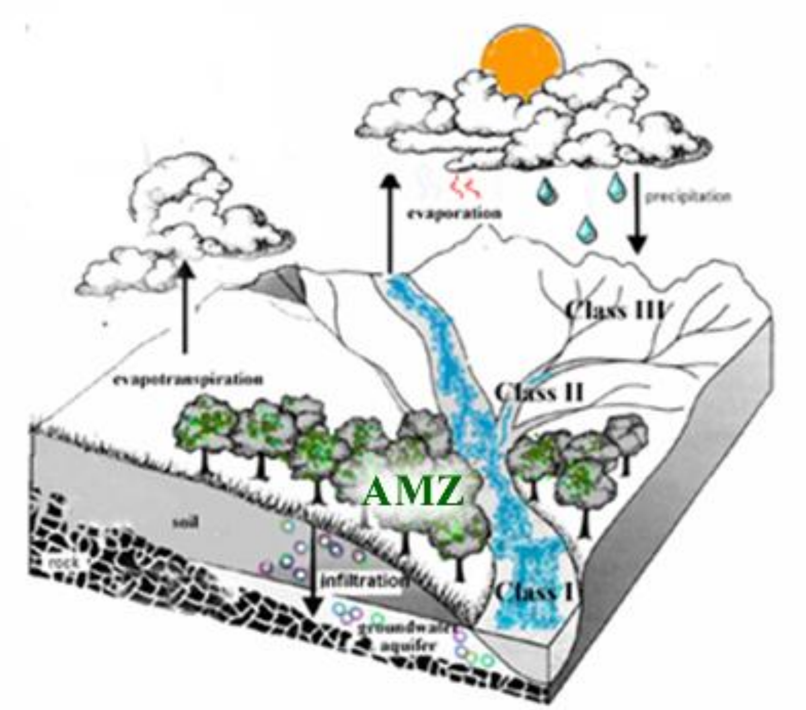


Figure 8-2 Stream Classes and Hydrologic Processes

8.2.1.1.3 AMZ bands

MRC will counteract disturbance within the AMZ with three bands: inner, middle, and outer (Figure 8-3). Disturbance will vary across these bands, with the least disturbance in the inner band.

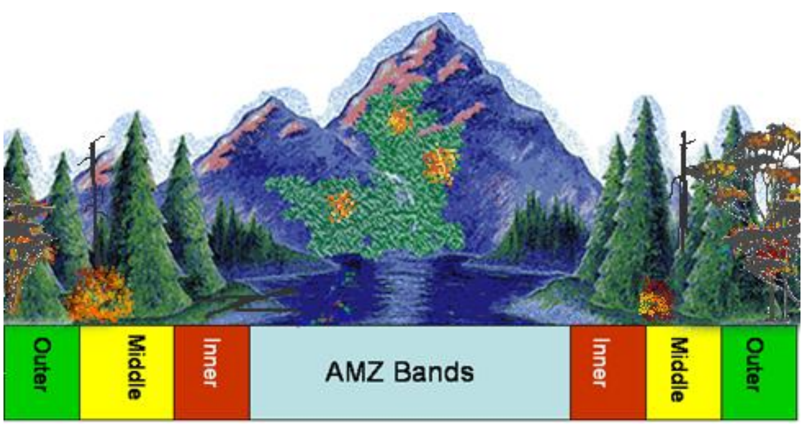


Figure 8-3 AMZ Bands for Class I and Large Class II Streams and Rivers

MRC will delineate AMZ bands on the largest streams or rivers—Class I and Large Class II—where fish and amphibian species, covered by our HCP/NCCP, are present. For smaller streams—Small Class II and Class III— where covered fish are never present and amphibians are seldom present year round, there will be one continuous band. Table 8-2 outlines the riparian functions for each of the AMZ bands.

Table 8-2 Riparian Function within Bands of the AMZ

Bands	Riparian Function
Inner[5]	• Recruit LWD. • Promote stream shade with canopy and cool streamside microclimate. • Promote nutrient cycling within the floodplain. • Provide coarse and fine organic inputs. • Provide hydraulic roughness on the floodplain. • Promote streambank stability. • Provide sediment filtration.
Middle	• Recruit LWD. • Promote stream shade with canopy and cool streamside microclimate. • Provide coarse and fine organic inputs. • Provide sediment filtration.
Outer	• Buffer inner and middle band processes from upslope management. • Retain canopy to moderate microclimate within inner and middle bands. • Recruit LWD from trees toppling into inner or middle band.

8.2.2 Goal and objectives

Goal and Objectives for Riparian Function	
Goal	
G§8.2.2-1	Conserve and develop streamside stands with large, dense conifer species to (1) increase riparian function; (2) create and enhance habitat for covered anadromous salmonid and amphibian species; and (3) protect beneficial uses of water.
Objectives	
Riparian Stands	
O§8.2.2-1	Develop and maintain Class I and Large Class II AMZs based on targets for basal area and size distribution (see Table 8-5 through Table 8-7 and Appendix U, *Inventory Strategy*).
O§8.2.2-2	Achieve, per planning watershed, at least 70% canopy averaged across the entire Class I and Large Class II AMZ.[6] ▪ More than 75% of the stands sampled during timber inventories will meet this canopy requirement within 30 years of HCP/NCCP initiation. ▪ More than 90% of the stands sampled during timber inventories will meet this canopy requirement within 70 years of HCP/NCCP initiation (Table 8-3).

[5] These functions apply to the entire AMZ of Small Class II and Class III watercourses with one exception. The requirement to promote stream shading to moderate summer water temperatures does not apply to Small Class II and Class III watercourses.

[6] This objective arises from the AMZ conservation measure (C§8.2.3.1.2-1) to close up riparian canopy in Class I and Large Class II AMZs so that inner bands, middle bands, and outer bands have at least 85%, 70%, and 50% canopy, respectively.

Goal and Objectives for Riparian Function	
O§8.2.2-3	Manage for a mix of tree species in the AMZs that closely resembles the following conditions: ▪ More than 45% of vegetation strata[7] in riparian stands will be conifer/hardwood or conifer-dominated 40 years after HCP/NCCP initiation. ▪ More than 90% of vegetation strata in riparian stands will be conifer/hardwood or conifer-dominated 70 years after HCP/NCCP initiation.
Instream Conditions	
O§8.2.2-4	Increase the amount of instream LWD to improve the quality of aquatic habitat in Class I and Class II watercourses (see Appendix S, *Targets for LWD and Effective Shade*).
O§8.2.2-5	Increase pool frequency, residual pool depth, or residual pool volumes as measured at the stream reach scale through LWD recruitment (see Appendix S, *Targets for LWD and Effective Shade*).
O§8.2.2-6	Decrease summer water temperatures, where possible, to manage for temperatures at or below MWMT targets for covered species (see the *Water Quality Control Plan for the North Coast Region*, i.e., the Basin Plan).
O§8.2.2-7	Achieve *on-target* ratings for both stream shade and LWD at the planning watershed scale (see Appendix S, *Targets for LWD and Effective Shade*).

8.2.2.1 80-year projections for timber stands

The histograms in Figures 8-4 and 8-5 show (a) average conditions for a subset of Class I and Class II AMZs at Year 50 of HCP/NCCP implementation and (b) projected average basal area and tree density for these same stands under pre-harvest conditions at Year 70 and post-harvest conditions at Year 75. The subset comprises 128 stands from 8 different planning watersheds across all the MRC inventory blocks within the plan area. Years 70 and 75 represent stands that are in regulated states of growth and harvest, i.e., the stands have the required basal areas to meet the retention levels for each size class. Our landscape model simulates growth in 5-year increments. As a result, our post-harvest conditions include in-growth (new seedlings in the 0-8 in. dbh class) as well as growth (residual trees retained) across all diameter classes. Figures 8-4 and 8-5 show that AMZ stands will have a more even distribution of size classes post-harvest, but trees in the larger size classes will still dominate the stands. On the other hand, Figure 8-6 and Tables 8-3 through 8-8 incorporate data for all Class I and Large Class II AMZ stands. They demonstrate that tree density will decrease in AMZ stands while trees in the larger diameter classes will increase across the plan area.

Table 8-3 projects AMZ canopy cover by planning watershed. These values represent canopy cover averaged across the Class I and Large Class II AMZs. At this time, our inventory is not robust enough within the AMZs to give accurate data at the planning watershed level. Currently AMZ stands are not distinguishable from upslope stands. The data within Table 8-3 comes from a computer program which uses structure classes to model canopy. However, our timber inventory monitoring program will include actual AMZ canopy measurements. Data captured by foresters cruising stands in the field will provide a more accurate picture of AMZ conditions for

[7] MRC assigns a vegetation label, or strata, to a stand using aerial photos. This photo interpretation is the basis for a stratified sampling system to acquire vegetation data (see Appendix U, U.2.1, *Stratified sampling*).

subsequent reporting. In Table 8-3, we have designated Year 30 and Year 70 of HCP/NCCP implementation as benchmark years. Table 8-4, on the other hand, provides the anticipated AMZ harvest across the plan area throughout the term of our HCP/NCCP and beyond.

Objective O§8.2.2-3 describes MRC targets for managing a mix of tree species within AMZs. In an effort to re-construct earlier forest conditions, MRC researched aerial photos stored in our vault, published photos, Bureau of Land Management records, and anecdotes from individuals alive in the early 20th century. We also examined pre-European evidence, such as stumps and old trails. Visits to nearby preserves, like Hendy Woods, Montgomery Woods, Armstrong Woods, and Mailliard Reserve, reinforced our photographic and written evidence. From all this data, we concluded that currently there is a greater hardwood-to-conifer ratio in our plan area than existed before European intervention. Tanoak, in particular, has proliferated. We cannot determine the exact composition of these early forests since slight variations in site conditions can favor one species over another. Consequently, we have built into our conservation measures safeguards to ensure that hardwoods will remain as a valued species across the plan area.

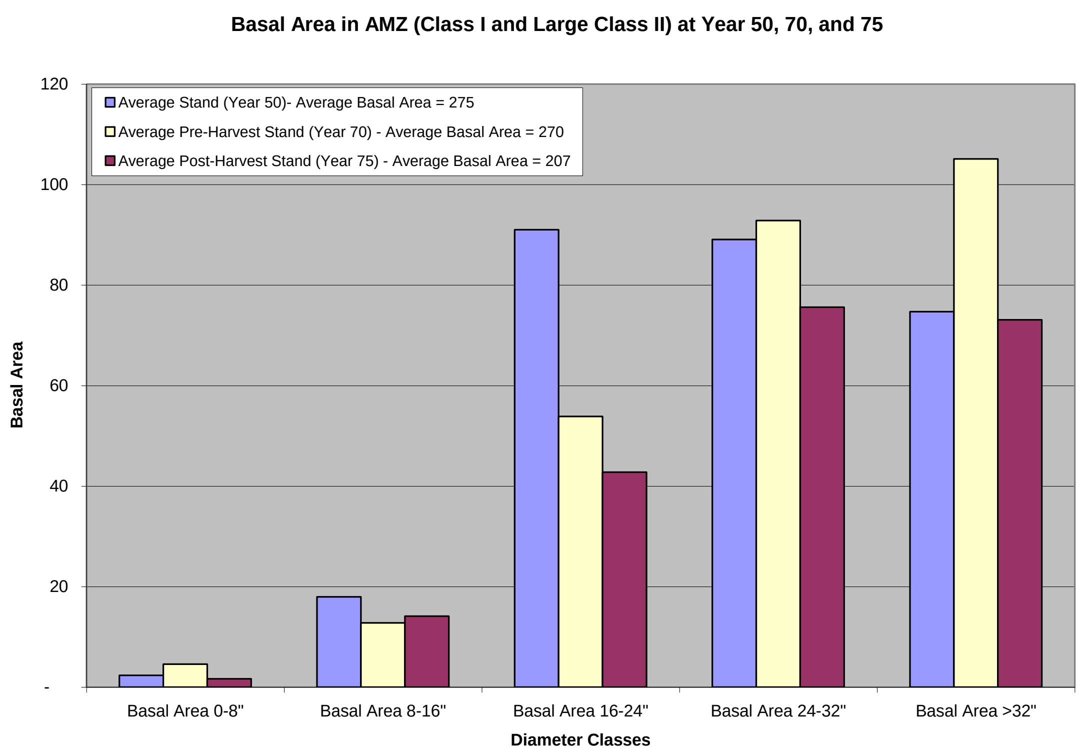


Figure 8-4 Basal Area in Class I and Large Class II AMZ

Figure 8-5 Tree Density in Class I and Large Class II AMZ

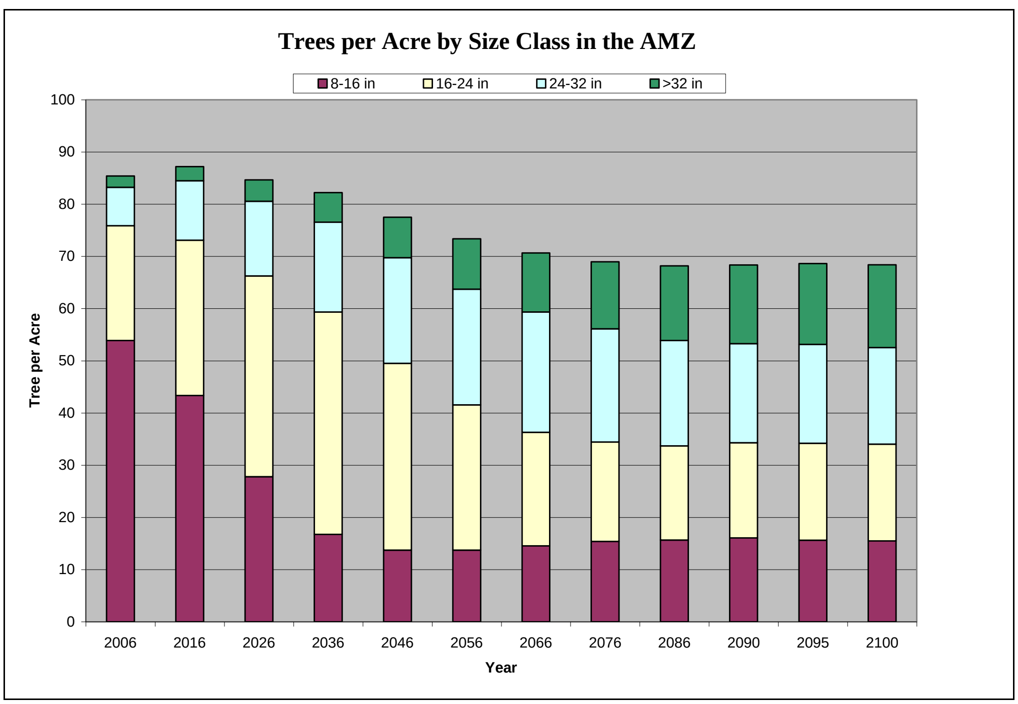


Figure 8-6 Trees per Acre in Inner and Middle Bands of Class I and Large Class II AMZ

Table 8-3 Current and Estimated Average AMZ Canopy Cover in Planning Watersheds

Current and Estimated Average AMZ Canopy Cover			
		Benchmark Years	
Planning Watershed	Current Canopy	Canopy Year 30	Canopy Year 70
	% Coverage		
Cottaneva Creek	83	84	89
Dutch Henry Creek	77	85	89
East Branch N.F. Big River	80	84	89
Flynn Creek	83	85	93
Hardy Creek	66	82	87
Hayworth Creek	72	84	86
Hendy Woods	84	85	88
Howard Creek	76	85	89
John Smith Creek	82	85	88
Juan Creek	68	84	88
Little North Fork Navarro River	69	82	86
Little River	85	85	89
Lower Albion River	83	86	93
Lower Alder Creek	74	85	90
Lower Elk Creek	73	84	87
Lower Greenwood Creek	83	85	86
Lower Hollow Tree Creek	67	85	88
Lower Navarro River	82	85	90
Lower North Fork Big River	82	85	89
Lower South Branch Navarro River	78	85	88
Mallo Pass Creek	68	84	89
Martin Creek	81	85	90
McMullen Creek	78	85	86
Mettick Creek	69	84	89
Middle Albion River	82	84	91
Middle Fork Noyo River	69	84	85
Middle Hollow Tree Creek	77	85	92
Middle Navarro River	78	85	91
Middle South Branch Navarro River	64	84	88
Mill Creek	82	83	87
North Fork Garcia River	72	81	89
North Fork Indian Creek	67	81	88
North Fork Navarro River	85	87	90
North Fork Noyo River	64	83	88
Olds Creek	76	82	85
Point Arena Creek	84	85	89
Ray Gulch	78	88	92
Redwood Creek	40	84	87
Rolling Brook	82	85	87
Russell Brook	83	85	90
Russian Gulch	85	85	86

Current and Estimated Average AMZ Canopy Cover			
		Benchmark Years	
Planning Watershed	Current Canopy	Canopy Year 30	Canopy Year 70
	% Coverage		
South Daugherty Creek	62	85	89
South Fork Albion River	77	85	92
South Fork Garcia River	71	85	87
Two Log Creek	73	85	89
Upper Ackerman	76	81	85
Upper Albion River	83	86	91
Upper Elk Creek	81	85	89
Upper Greenwood Creek	82	85	89
Upper Hollow Tree Creek	65	84	88
Upper Navarro River	74	85	88
Upper Noyo River	84	85	89
Upper South Branch Navarro River	66	85	88

Table 8-4 Projected Harvest in Inner and Middle Bands of Class I and Large Class II AMZ

Major River	**AMZ Gross Acres**	***Projection Periods in the Plan Area**				
		HCP/NCCP Time Period				Beyond
		Years 0-20 (ac)	Years 20-40 (ac)	Years 40-60 (ac)	Years 60-80 (ac)	Years 80-100 (ac)
Albion	1508	83	381	999	1188	1176
Big River	3415	10	720	1376	2724	2917
Garcia River	1377	92	432	811	983	1136
Navarro	5212	180	1232	2829	3923	4103
Hollow Tree (SF Eel)	2011	0	354	1606	1853	1861
Noyo	1677	31	347	887	1425	1443
Cottaneva, Howard, Hardy, Juan	1519	0	112	792	1216	1204
Alder, Elk, Greenwood, Mallo Pass	3487	19	1442	2544	2745	2907
Russian	240	0	5	5	19	81
Albion	1508	83	381	999	1188	1176
Totals for Plan Area	20,446	**416**	**5,025**	**11,849**	**16,077**	**16,828**
Percentage of Total AMZ		**2.0%**	**24.6%**	**58.0%**	**78.6%**	**82.3%**

TABLE NOTE

*The MRC landscape model simulates harvest of stands in 20-year increments.

In Tables 8-5 through 8-8, we have provided projections, based on our landscape model, of tree sizes and distribution during the 80-year term of our HCP/NCCP. The data in these tables is for forested stands only and does not include pygmy forest, oak woodland, grasslands, brush, or

rocky outcrops. In the tables, we have averaged the projected targets for tree size and distribution across our land; individual stand conditions will vary.
Table 8-5 through Table 8-7 shows tree size and distribution by site class. Site class is a relative measure of forest productivity. There are 5 site classes. The California Public Resources Code (PRC) 4528(d) divides the 5 site classes into 3 categories. Site Class I denotes lands of the highest productivity, i.e., those in the flood plain or channel migration zones. Site Classes II and III denote lands of intermediate productivity, and Site Classes IV and V denote lands of the lowest productivity. MRC maintains the same delineation for site classes as the PRC as these are the stocking standards, per site class, that we must abide by after implementation of our HCP/NCCP. Therefore, for management consistency, MRC lumps Site Class II with Site Class III, and Site Class IV with Site Class V. As a whole, MRC forests are primarily in Site Class III. The majority of AMZ stands in the plan area are either Site Class II or III.

The dates 2047 and 2082, represented by shaded rows in Tables 8-5 through 8-8, signal benchmarks when MRC and the wildlife agencies will review timber inventory objectives to determine whether MRC is meeting those objectives and to negotiate any necessary adjustments in the objectives. These dates are equivalent to Year 35 and Year 70, respectively, of HCP/NCCP implementation, assuming that our HCP/NCCP commences in 2012.

Table 8-5 Trees per Acre by DBH in Site Class II and III

Inner and Middle Bands of Large Class I and Large Class II AMZ Trees in Site Class II and Site Class III					
Dates during HCP/NCCP Term	DBH (in.)				Average Basal Area of Stands (sq ft/ac)
	8-16	16-24	24-32	>32	
	Trees Per Acre				
2012	47	18	6	2	117
2017	46	21	7	2	127
2022	43	24	8	2	139
2027	40	28	9	3	151
2031	35	31	10	3	163
2037	31	33	12	4	173
2042	26	33	13	4	182
2047	22	33	15	5	191
2052	19	33	16	6	199
2057	16	31	17	7	207
2062	14	29	19	8	212
2067	13	27	19	9	215
2072	13	25	19	9	215
2077	14	22	19	10	218
2082	15	21	19	11	221
2087	14	20	21	11	225
2092	14	20	21	12	227

Table 8-6 Trees per Acre by DBH in Site Class I

Inner and Middle Bands of Large Class I and Large Class II AMZ Trees in Flood Plain or Channel Migration Zones (CMZ)					
Dates during HCP/NCCP Term	DBH (in.)				Average Basal Area of Stands (sq ft/ac)
	8-16	16-24	24-32	>32	
	Trees Per Acre				
2012	37	18	11	7	168
2017	37	20	12	8	178
2022	34	22	12	8	189
2027	31	25	13	9	201
2031	28	27	14	10	212
2037	25	28	14	11	222
2042	23	28	15	12	232
2047	20	29	16	13	241
2052	18	28	17	13	245
2057	17	28	17	14	252
2062	16	26	19	14	254
2067	16	25	20	14	256
2072	17	24	20	14	259
2077	17	23	20	15	263
2082	19	22	21	15	264
2087	18	21	21	15	266
2092	18	21	22	16	269

Table 8-7 Site Class IV and V Trees per Acre by DBH

Inner and Middle Bands of Large Class I and Large Class II AMZ Trees in Site Class IV and Site Class V					
Dates during HCP/NCCP Term	DBH (in.)				Average Basal Area of Stands (sq ft/ac)
	8-16	16-24	24-32	>32	
	Trees Per Acre				
2012	32	11	4	1	74
2017	31	13	5	1	81
2022	28	16	5	1	89
2027	25	18	6	2	97
2031	20	21	7	2	106
2037	15	24	8	3	117
2042	12	24	9	3	127
2047	10	23	11	4	134
2052	8	22	13	5	147
2057	6	21	14	6	153
2062	5	18	16	7	159
2067	5	15	16	8	164
2072	5	12	16	10	168
2077	5	10	15	11	168
2082	5	9	14	11	170
2087	5	8	15	11	173
2092	5	7	15	12	175

Table 8-8 Number of Trees and Average Tree Height

Inner and Middle Bands of Class I and Large Class II AMZ					
Dates during HCP/NCCP Term	DBH (in.) 24-32		DBH (in.) >32		Average Tree Height (>24 in.)
	Average Height	Trees per Acre	Average Height	Trees per Acre	
2012	115	8	117	3	116
2017	119	9	121	3	119
2022	122	10	131	3	124
2027	123	11	139	4	127
2031	128	12	145	4	133
2037	130	13	148	5	135
2042	133	15	153	6	138
2047	134	17	155	6	140
2052	135	18	158	7	141
2057	136	20	160	8	143
2062	138	20	163	9	145
2067	139	21	164	10	147
2072	141	21	168	10	150
2077	142	21	169	11	151
2082	144	20	170	12	153
2087	146	21	173	12	156
2092	149	22	176	12	159

In conjunction with Tables 8-5 through 8-8, Tables 8-9 and 8-10 give the range of basal area and trees per acre of Class I and Large Class II AMZ stands.

Table 8-9 Range of Basal Area for Class I and Large Class II AMZ Stands

		Diameter Classes				
		0-8"	8-16"	16-24"	24-32"	>32"
Year 2050	min	2	5	71	71	34
	max	3	50	114	113	111
Year 2070	min	2	8	37	65	78
	max	19	15	82	111	135
Year 2075	min	1	10	20	63	62
	max	2	18	61	85	86

Table 8-10 Range of Trees per Acre for Class I and Large Class II AMZ Stands

		Diameter Classes				
		0-8"	8-16"	16-24"	24-32"	>32"
Year 2050	min	12	20	33	19	5
	max	40	79	53	26	14
Year 2070	min	14	16	17	15	9
	max	42	41	31	29	18
Year 2075	min	32	16	10	15	8
	max	59	35	27	22	11

8.2.3 Conservation measures

8.2.3.1 Class I and Large Class II AMZ

The AMZ will incorporate conservation measures that affect different riparian processes. A management action within a Class I or Large Class II AMZ must meet a combination of restrictions. The conservation measures for such areas are organized by these restrictions:

- AMZ band widths.
- Canopy retention.
- Basal area retention.
- Largest tree retention.
- Silviculture.
- Flood-prone zones.
- Streambank stability.
- Heavy equipment limitations.
- Soil pipes.
- Bare soil.
- Cable corridors.

In order to promote and maintain riparian function, MRC will retain large trees and overstory canopy within AMZs and limit equipment disturbances at sufficient widths from a stream channel. We will exclude equipment from AMZs unless use of such equipment is for restoration purposes or actually reduces environmental impacts, e.g., traveling over roads in the AMZ to repair a damaged culvert. There will be a *no harvest zone* for all non-sprouting species within 10 ft of all Class I, Class II, and Class III watercourses; however, we will allow limited harvest within redwood clumps. MRC has mapped flood-prone areas or channel migration zones along Class I watercourses; these will receive greater basal-area standards and increased AMZ width, where needed, for maintenance of floodplain and riparian interactions.

In some cases, due to past management, an AMZ does not provide a desired level of riparian function. Areas with unnaturally high levels of hardwood, overstocked stands of young even-aged conifers, or stands with poor-growing conifer trees can provide greater riparian function in the long-term with some restorative vegetation management. We will limit the amount and extent of these restoration treatments and regulate them through monitoring and adaptive management. This will ensure that such treatments do not adversely affect the covered aquatic species. In addition to the AMZ, MRC will create buffer areas to retain canopy, exclude equipment disturbances, and maintain habitat features in wetlands or wet meadows, seeps, springs, and wet areas.

8.2.3.1.1 AMZ band widths

	Conservation Measures for Band Widths Class I and Large Class II AMZ
C§8.2.3.1.1-1	Establish AMZ widths by watercourse class and slope class.

Watercourse	Slope Class (%)	AMZ Band Widths***		
		Inner	Middle*	Outer
Class I	0-30	0-50	50-100	100-130
	30-50	0-50	50-130	130-150
	>50	0-50	50-150**	150**-190
Large Class II	0-30	0-25	25-50	50-100
	30-50	0-25	25-75	75-130
	>50	0-25	25-100**	100**-150

TABLE NOTES

* Flood-prone and channel migration zones on Class I watercourses can adjust these dimensions. The middle band starts on the outer edge of the flood prone or channel migration zones.

** Adjust 20-25 ft for cable and helicopter yarding operations adjacent to Class I and Class II AMZ, respectively. In effect, as the outer edge of the middle band "shrinks", the inner edge of the outer band "expands" (see Figure 8-7).

***Measured along the slope distance from the bankfull channel or channel migration zone boundary.

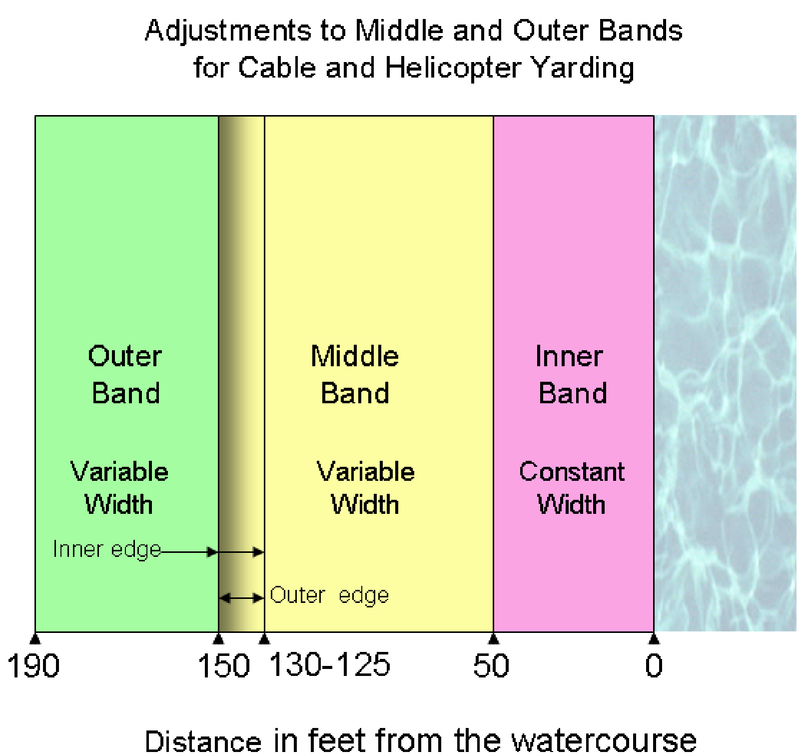


Figure 8-7 Adjusting Middle and Outer Bands

8.2.3.1.2 *Canopy*

DEFINITION	Canopy is the amount of vegetation or topography that blocks out the vertical projection of the sky; sun angle does not affect canopy

When selecting trees for harvest, an MRC forester will use professional judgment and ocular estimation to determine the percentage of canopy retention. If there is a disagreement about the canopy retention before, during, or after harvest, the forester will meet with the disputant to agree upon a sampling intensity and to make further observations using a sight tube per CAL FIRE protocol (Anon. 1999).

	Conservation Measures for Canopy Retention Class I and Large Class II AMZ
C§8.2.3.1.2-1	Develop or retain canopy in the inner, middle, and outer band of the AMZ. ▪ Inner band: 85% canopy. ▪ Middle band: 70% canopy. ▪ Outer band: 50% canopy. **NOTE** MRC will use these AMZ canopy targets during PTHP compliance monitoring to assess canopy cover after harvesting. Timber inventory monitoring, however, will assess canopy cover by planning watershed and will set a target of 70% canopy across all 3 bands rather than stratifying the target by AMZ band. The un-weighted average of the 3 bands is approximately 70%. See Appendix U, *Inventory Strategy*.

8.2.3.1.3 Basal area retention

The inner and middle bands of Class I and Large Class II AMZ will have basal area retention based on the site class of the AMZ. AMZ basal area is the average basal area across the width of each inner and middle band for a linear distance of 330 ft (≈100 m). The average of the summed widths of the inner and middle bands multiplied by a distance of 330 ft is approximately 1 ac.

	Conservation Measures for Basal Area Retention Inner and Middle Bands Class I and Large Class II AMZ
Pre-harvest condition for Site Class I: ≥ 300 ft^2/ac of conifer basal area	
C§8.2.3.1.3-1	Retain in Site Class I, **post harvest**, 240 ft^2/ac or 75% of the pre-harvest basal area, whichever is greater.
Pre-harvest condition for Site Class II or III: ≥ 260 ft^2/ac of conifer basal area	
C§8.2.3.1.3-2	Retain in Site Class II or III, **post harvest**, 200 ft^2/ac or 75% of the pre-harvest basal area, whichever is greater.
Pre-harvest condition for Site Class IV or V: ≥ 220 ft^2/ac of conifer basal area	
C§8.2.3.1.3-3	Retain in Site Class IV and V, **post harvest**, 160 ft^2/ac or 75% of the pre-harvest basal area, whichever is greater. **NOTE** If a pre-harvest condition does not apply, MRC will not harvest in the bands of the AMZ. In addition, these conservation measures only apply to the inner and middle bands of the AMZ; the outer band does not have basal area targets. In most cases, when pre-harvest conditions are met or exceeded, harvest will occur in the middle band rather than the inner band.

8.2.3.1.4 Largest tree retention

<table>
<tr><th colspan="2">Conservation Measures for Largest Tree Retention
Class I and Large Class II AMZ</th></tr>
<tr><td colspan="2">Large Tree Retention</td></tr>
<tr><td>C§8.2.3.1.4-1</td><td>Retain a percentage of the largest trees based on channel sensitivity to LWD.
▪ High sensitivity: retain 30% in inner band, 15% in middle band.
▪ Moderate sensitivity: retain 20% in inner band, 10% in middle band.
▪ Low sensitivity: retain 10% in inner band, 5% in middle band.

NOTE
▫ MRC identifies the sensitivity of stream channels within watershed analysis. For areas in which we have not conducted a watershed analysis, we will identify sensitivity on a site-by-site basis with the assistance of staff hydrologists, geomorphologists, or aquatic biologists.

▫ MRC will calculate, prior to each entry into an AMZ stand, the percentage of large conifer trees for retention. The percentage applies to trees with at least a 12 in. dbh. Selection of the largest trees will progress systematically through size classes demarcated at 4 in. (dbh) intervals, beginning with the largest size class. For example, if the largest tree retention standard is 20% and 100 trees are ≥ 12 in. dbh within the band, then MRC will retain the 20 largest trees in addition to all other AMZ requirements. In determining the largest trees retained, MRC will start with the largest size class and work backward to the next largest size class and so forth. In addition, MRC will retain all trees leaning across the plane of the channel zone, even if they are not one of the largest trees. In effect, this means that the stem of the tree (from the point where it reaches 6 in. in diameter and above) crosses the plane of the bankfull channel.</td></tr>
<tr><td colspan="2">Exchanging Retention Trees</td></tr>
<tr><td>C§8.2.3.1.4-2</td><td>Apply the following rules if 2 or more potential retention trees are within the same redwood clonal group:
1. Designate the largest tree within the redwood clonal group as the retention tree, if operationally feasible; otherwise
2. Substitute another tree outside this redwood clonal group which is the same size class or next available size class as that designated largest tree.

NOTE
The purpose of this conservation measure is to replace any large tree which is harvested and to space out the large retention trees throughout the AMZ.</td></tr>
</table>

	Conservation Measures for Largest Tree Retention Class I and Large Class II AMZ
C§8.2.3.1.4-3	Substitute a tree for a large retention tree even though it does not meet the standards for large tree retention if (a) the HCP/NCCP or a report from a professional geologist dictates its retention to provide erosion control or mass wasting stability and (b) it meets the eligibility requirements in C§8.2.3.1.4-5. **NOTE** Apart from the prescriptions in C§8.2.3.1.4-2, MRC may only trade a large retention tree with another tree for operational purposes, such as cable line restrictions (C§8.2.3.1.10-2) or felling and skidding limitations. The limitations on trade trees are (a) 10% of large trees within an AMZ per PTHP during the first 10 years of the HCP/NCCP and (b) 15% of large trees within an AMZ per PTHP from Years 11-20 of HCP/NCCP implementation. After Year 20, MRC may trade up to 20% of large trees per PTHP within an AMZ. Harvesting of a trade tree within an AMZ can only occur if the 1. AMZ meets its requirements for canopy and basal area. 2. Tree is not one of the largest retention trees or within 10 ft of the bankfull channel. 3. AMZ streams, in locations where harvests are occurring, meet their LWD targets. 4. Cumulative number of trade trees during the term of the HCP/NCCP account for no more than 40% of the large trees within an AMZ stand.
C§8.2.3.1.4-4	Mark a smaller tree that becomes a retention tree as part of a trade to ensure it will be retained and is no longer eligible as a trade tree during subsequent harvest entries.
Qualifying as a Trade Tree	
C§8.2.3.1.4-5	Follow the rule that a tree is eligible for trade with a retention tree ▪ If it is the next largest individual tree in sequence after the full complement of trees has been retained. ▪ If it leans out toward the active channel, is likely to recruit in the near future, and is in the top 50 percentile of tree size for that AMZ band.

Table 8-11 provides examples of how many trees MRC would potentially retain based on stocking levels of stands, channel sensitivity, standards for basal area retention (C§8.2.3.1.3-1 to C§8.2.3.1.3-3), and AMZ band. Stocking levels show the amount of trees retained at different stocking densities.

Characteristics of AMZ stands vary across the plan area. Some AMZ stands are dominated by small trees, some by large trees, while others have a mix of both. The designations for stand stocking in Table 8-11 (namely, *poor*, *moderate*, and *well*) are for hypothetical stands; the stands represent a range of conditions across the plan area. Likewise, Table 8-11 shows a hypothetical result for an allowable harvest given the conservation measures for large tree and basal area retention. In practice, the retention would likely be greater because of additional conservation measures cited in this chapter. The guidelines for canopy retention, for example, might limit the potential harvest more than measures for large tree and basal area retention.

Table 8-11 Large Tree and Basal Area Retention

Class I and Large Class II AMZ (Inner and Middle Bands)																				
Stand Stocking	**Channel Sensitivity/Band**	**Pre Harvest # of Trees dbh (in.)**							**Total Trees > 4 in.**	**Pre Harvest Basal Area (sq. ft)**	**Post Harvest # of Trees dbh (in.)**							**Total Trees < 4 in.**	**Post Harvest Basal Area (sq. ft)**	**Minimum Number of Largest Trees Retained**
		4-11	**12-16**	**17-20**	**21-24**	**25-28**	**29-32**	**>32**			**4-11**	**12-16**	**17-20**	**21-24**	**25-28**	**29-32**	**>32**			
Poor	High/Inner	12	17	15	10	6	5	1	66	127	12	17	15	10	6	5	1	66	127	**ALL**
Poor	High/Middle	12	17	15	10	6	5	1	66	127	12	17	15	10	6	5	1	66	127	**ALL**
Poor	Moderate/Inner	12	17	15	10	6	5	1	66	127	12	17	15	10	6	5	1	66	127	**ALL**
Poor	Moderate/Middle	12	17	15	10	6	5	1	66	127	12	17	15	10	6	5	1	66	127	**ALL**
Poor	Low/Inner	12	17	15	10	6	5	1	66	127	12	17	15	10	6	5	1	66	127	**ALL**
Poor	Low/Middle	12	17	15	10	6	5	1	66	127	12	17	15	10	6	5	1	66	127	**ALL**
Moderate	High/Inner	12	16	16	14	15	10	14	97	288	9	16	13	10	5	10	14	77	219	**29**
Moderate	High/Middle	12	16	16	14	15	10	14	97	288	9	16	14	12	3	10	14	78	218	**15**
Moderate	Moderate/Inner	12	16	16	14	15	10	14	97	288	9	16	16	12	9	5	14	81	220	**19**
Moderate	Moderate/Middle	12	16	16	14	15	10	14	97	288	9	16	16	12	10	8	10	81	216	**10**
Moderate	Low/Inner	12	16	16	14	15	10	14	97	288	9	16	16	12	10	8	10	81	216	**10**
Moderate	Low/Middle	12	16	16	14	15	10	14	97	288	9	16	16	14	15	9	5	84	218	**5**
Well	High/Inner	8	12	13	17	20	14	18	102	352	6	12	10	10	10	13	18	79	265	**31**
Well	High/Middle	8	12	13	17	20	14	18	102	352	6	12	13	17	17	12	10	87	267	**10**
Well	Moderate/Inner	8	12	13	17	20	14	18	102	352	6	12	13	17	18	2	18	86	265	**20**
Well	Moderate/Middle	8	12	13	17	20	14	18	102	352	6	12	13	17	18	11	10	87	266	**10**
Well	Low/Inner	8	12	13	17	20	14	18	102	352	6	12	13	16	14	14	10	85	263	**10**
Well	Low/Middle	8	12	13	17	20	14	18	102	352	6	12	13	17	20	14	6	88	266	**5**

8.2.3.1.5 *Silviculture*

The conservation measures that follow do not apply to rehabilitation sites.

	Conservation Measures for Silviculture Class I and Large Class II AMZ
Inner Band	
C§8.2.3.1.5-1	Apply silvicultural treatments to develop or maintain late seral forest conditions, such as thinning from below or individual tree selection.
C§8.2.3.1.5-2	Use high retention selection that meets basal area and canopy requirements.
C§8.2.3.1.5-3	Maintain or increase conifer dominance—if necessary, by controlling hardwoods.
C§8.2.3.1.5-4	Ensure that redwood clonal groups or “clumps” have no more than 50% of their stems greater than 8 in. dbh removed per entry.
C§8.2.3.1.5-5	Do not harvest trees from the inner band if shelterwood or seed tree removal occurs in the outer band for that rotation.
C§8.2.3.1.5-6	Do not sanitize or salvage LWD that is within the bankfull channel; retain all downed LWD in the AMZ unless the AMZ meets its LWD targets.
C§8.2.3.1.5-7	Harvest snags in the AMZ only with the approval of the wildlife agencies.
C§8.2.3.1.5-8	Leave, as a first priority, LWD previously designated as a large retention tree or wildlife tree.
C§8.2.3.1.5-9	Do not initiate prescribed burning in Small Class II AMZ.
C§8.2.3.1.5-10	Permit fire control lines for controlled burning in Small Class II AMZs only with concurrence of the wildlife agencies.
C§8.2.3.1.5-11	Allow salvage harvest in an AMZ only with concurrence of the wildlife agencies.
C§8.2.3.1.5-12	Allow harvest of a minimum merchantable length log from any LWD that obstructs a road.
C§8.2.3.1.5-13	Avoid damage or destruction to non-commercial vegetation beyond the minimum disturbance required for covered activities.
C§8.2.3.1.5-14	Retain all old-growth trees. **NOTE** If the RPF determines that the inner zone is over-stocked with trees <16 in. dbh and that this is limiting future growth, MRC may request the wildlife agencies to advise the RPF which trees to harvest in order to more quickly reach the objectives of the HCP/NCCP.
Middle Band	
C§8.2.3.1.5-15	Apply silvicultural treatments to develop or maintain late seral forest conditions, such as thinning from below or individual tree selection.
C§8.2.3.1.5-16	Use high retention selection that meets basal area and canopy requirements.

	Conservation Measures for Silviculture Class I and Large Class II AMZ
C§8.2.3.1.5-17	Maintain or increase conifer dominance—if necessary, by controlling hardwoods.
C§8.2.3.1.5-18	Do not harvest trees from the middle band if shelterwood or seed tree removal occurs in the outer band for that rotation, unless this is an AMZ restoration harvest.
C§8.2.3.1.5-19	Do not sanitize or salvage LWD that is within the bankfull channel; retain all downed LWD in the AMZ unless the AMZ meets its LWD targets.
C§8.2.3.1.5-20	Leave, as a first priority, LWD previously designated as a large retention tree or wildlife tree.
C§8.2.3.1.5-21	Allow salvage harvest in an AMZ only with concurrence of the wildlife agencies.
C§8.2.3.1.5-22	Allow harvest of a minimum merchantable length log from any LWD that obstructs a road.
C§8.2.3.1.5-23	Avoid damage or destruction to non-commercial vegetation beyond the minimum disturbance required for covered activities.
C§8.2.3.1.5-24	Retain all old-growth trees.
Outer Band	
C§8.2.3.1.5-25	Maintain or increase conifer dominance—if necessary, by controlling hardwoods.
C§8.2.3.1.5-26	Maintain, on average, 50% canopy within 330 ft (100 m) sections.
C§8.2.3.1.5-27	Limit harvest openings to ¼ ac in size.
C§8.2.3.1.5-28	Do not sanitize or salvage LWD that is within the bankfull channel; retain all downed LWD in the AMZ unless the AMZ meets its LWD targets.
C§8.2.3.1.5-29	Leave, as a first priority, LWD previously designated as a large retention tree or wildlife tree.
C§8.2.3.1.5-30	Allow salvage harvest in an AMZ where an adjacent upslope stand is "no harvest" only with concurrence of CDFG.
C§8.2.3.1.5-31	Allow harvest of a minimum merchantable length log from any LWD that obstructs a road.
C§8.2.3.1.5-32	Retain all old-growth trees.

8.2.3.1.6 Flood-prone zones

The majority of Class I stream channels within the plan area are topographically confined, with little capacity for channel migration or floodplain development. Some flood-prone or channel migration zones occur along the Navarro River, the lower portion of North Fork Navarro River, Albion River, South Fork Albion River, Cottaneva Creek, Juan Creek, and Garcia River (see *HCP/NCCP Atlas*, MAPS 3A-3C).

	Conservation Measures for Flood-prone Zones Class I AMZ
C§8.2.3.1.6-1	Retain 300 ft^2/ac of the conifer basal area or retain 75% of the pre-harvest basal area, whichever is greater.
C§8.2.3.1.6-2	Avoid damage or destruction to non-commercial vegetation in the flood-prone or channel migration zone beyond the minimum disturbance required for covered activities.
C§8.2.3.1.6-3	Extend the width of the middle band out to the base of a hillslope, if it does not already extend to or beyond that point.
C§8.2.3.1.6-4	Exclude all equipment, unless on existing roads or for use in road decommissioning.

8.2.3.1.7 Streambank stability

	Conservation Measures for Streambank Stability Class I and Large Class II AMZ
C§8.2.3.1.7-1	Retain all trees whose trunks (a) are within 10 ft of the bankfull channel or within 10 ft of a watercourse or lake transition zone where there is no delineated bankfull channel; or (b) have roots visible in the bank; or (c) provide anchor to an over-hanging bank, unless it is necessary to remove trees to create a cable corridor. **NOTE** Thinning of a redwood clonal group within 10 ft of a bankfull channel or within 10 ft of a watercourse or lake transition zone may also occur as long as MRC adheres to the guidelines for large tree retention.
C§8.2.3.1.7-2	Start the 10-ft retention zone at the landward edge of an undercut bank, using visual determination. **EXAMPLE** A bank is undercut by 5 ft. The retention zone will measure 10 ft from the depth of the undercut, i.e., 15 ft from the edge of the bank.
C§8.2.3.1.7-3	Ensure that redwood clonal groups or “clumps” have no more than 50% of their stems greater than 8 in. dbh removed per entry.
C§8.2.3.1.7-4	Follow 1 of these practices when trees, within the first 10 ft of the watercourse channel, are removed for cable corridors: ▪ Leave the trees in the AMZ for LWD. ▪ Place trees in the active channel as per the instream LWD enhancement guidelines, if feasible.

8.2.3.1.8 Equipment exclusion

	Conservation Measures for Equipment Exclusion Class I and Large Class II AMZ
C§8.2.3.1.8-1	Exclude all equipment in Class I and Large Class II AMZs unless there is an allowable use. **ALLOWABLE USE** ▪ *Erosion control or restoration* MRC may use a skid trail or landing one-time-only to control erosion or conduct restoration. Upon completing operations, we will decommission the skid trail or landing. ▪ *Existing skid trails, landings, or skid trail crossings* MRC may use—only rarely (perhaps 4 times a year)—an existing skid trail, landing, or designated skid trail crossing that does not require any reconstruction, if - Alternatives would create a greater risk and magnitude of sediment delivery. - Perched material is pulled back from landings and the landings shaped to prevent rill erosion by draining them into a rocked face outlet. - Surface areas >25 ft^2 are mulched, rocked, or covered in slash compacted by a tractor. ▪ *New skid trails, landings, or skid trail crossings* MRC may construct —only rarely (perhaps once every 3 years, lessening over time) and after obtaining approval of the wildlife agencies—a new skid trail, landing, or designated skid trail crossing if - Alternatives would create a greater risk and magnitude of sediment delivery. - All mitigations, approved by the wildlife agencies, are fully implemented. - All trees felled for construction of these new facilities in an AMZ within the inner and middle bands have the "key piece size" logs set aside for LWD placement, either in the vicinity of the new facilities or near watercourse sections deficient in LWD. ▪ *Existing Roads* MRC may use and maintain existing roads in AMZs. ▪ *New Roads* MRC may construct— only rarely (perhaps once every 3 years, lessening over time)—new roads to watercourse approaches within an AMZ if - The road does not parallel a watercourse. - Each approach on either side of a watercourse does not exceed 200 ft. - All trees felled for construction of these new facilities in an AMZ within the inner and middle bands have the "key piece size" logs set aside for LWD placement, either in the vicinity of the new facilities or near watercourse sections deficient in LWD. MRC may construct— only rarely (perhaps once every 3 years, lessening over time) and after obtaining approval of the wildlife agencies —a road segment not associated with a crossing or an approach to a crossing if - Alternatives would create a greater risk and magnitude of sediment delivery. - All mitigations, approved by the wildlife agencies, are fully implemented. - All trees felled in an AMZ for construction of these new facilities have the "key piece size" logs set aside for LWD

	Conservation Measures for Equipment Exclusion Class I and Large Class II AMZ
	placement, either in the vicinity of the new facilities or near watercourse sections deficient in LWD. ▪ *Watercourse crossing construction* MRC may use equipment to construct watercourse crossings.

8.2.3.1.9 Bare soil

	Conservation Measures for Bare Soil Class I and Large Class II AMZ
C§8.2.3.1.9-1	Treat, for erosion control, areas of exposed mineral soil which are (a) at least 100 ft^2 in size and (b) not on a running surface, with mulch, grass seed, slash, or other appropriate material; for running surfaces, see Appendix E, *Roads, Landings, and Skid Trails*.
C§8.2.3.1.9-2	Do not initiate prescribed or broadcast burning in the AMZ.

8.2.3.1.10 Cable corridors

	Conservation Measures for Cable Corridors Class I and Large Class II AMZ
C§8.2.3.1.10-1	Allow felled trees to remain in the AMZ for LWD or place the trees in the active channel as per instream LWD enhancement guidelines.
C§8.2.3.1.10-2	Harvest trees in a cable corridor only if the ▪ AMZ meets requirements for canopy and basal area. ▪ Tree is not one of the largest retention trees or within 10 ft of the bankfull channel. ▪ Streams meet LWD targets.

8.2.3.2 Small Class II AMZ

Management operations within a Small Class II AMZ must meet a combination of restrictions. The conservation measures for such areas are organized by these restrictions:

- AMZ band width.
- Canopy.
- Silviculture.
- Streambank stability.
- Equipment exclusion.
- Soil pipes.
- Bare soil.

8.2.3.2.1 AMZ band width

	Conservation Measures for Small Class II AMZ Widths
C§8.2.3.2.1-1	Establish AMZ widths. ▪ 0-30% slope = 50 ft ▪ 30-50% slope = 75 ft ▪ > 50% slope = 100 ft **NOTE** For slopes > 50%, MRC may subtract 25 ft from the AMZ width for cable and helicopter yarding.

8.2.3.2.2 Canopy

	Conservation Measures for Canopy Small Class II AMZ
C§8.2.3.2.2-1	Maintain, on average, 50% canopy over the width of the AMZ within 330 ft (100 m) segments.

8.2.3.2.3 Silviculture

	Conservation Measures for Silviculture Small Class II AMZ
C§8.2.3.2.3-1	Maintain or enhance uneven-aged conditions.
C§8.2.3.2.3-2	Harvest so that trees are dispersed in a relatively uniform manner.
C§8.2.3.2.3-3	Maintain or increase conifer dominance—if necessary, by controlling hardwoods.
C§8.2.3.2.3-4	Do not sanitize or salvage LWD that is within the bankfull channel; retain all downed LWD in the AMZ unless the AMZ meets its LWD targets.
C§8.2.3.2.3-5	Leave, as a first priority, LWD previously designated as a large retention tree or wildlife tree.
C§8.2.3.2.3-6	Do not initiate prescribed burning in Small Class II AMZ.
C§8.2.3.2.3-7	Permit fire control lines in Small Class II AMZs only with concurrence of the wildlife agencies.
C§8.2.3.2.3-8	Allow salvage harvest in an AMZ only with concurrence of the wildlife agencies.
C§8.2.3.2.3-9	Allow harvest of a minimum merchantable length log from any LWD that obstructs a road.
C§8.2.3.2.3-10	Avoid damage or destruction to non-commercial vegetation beyond the minimum disturbance required for covered activities.
C§8.2.3.2.3-11	Retain all old-growth trees.

8.2.3.2.4 Streambank stability

	Conservation Measures for Streambank Stability Small Class II AMZ
C§8.2.3.2.4-1	Retain all trees whose trunks (a) are within 10 ft of the bankfull channel or within 10 ft of a watercourse or lake transition zone where there is no delineated bankfull channel; or (b) have roots visible in the bank; or (c) provide anchor to an over-hanging bank, unless it is necessary to remove trees to create a cable corridor. **NOTE** MRC may also thin a redwood clonal group within 10 ft of the bankfull channel or within 10 ft of a watercourse or lake transition zone if they follow the large tree retention guidelines.
C§8.2.3.2.4-2	Start the 10-ft retention zone at the landward edge of an undercut bank, using visual determination. **EXAMPLE** A bank is undercut by 5 ft. The retention zone will measure 10 ft from the depth of the undercut, i.e., 15 ft from the edge of the bank.
C§8.2.3.2.4-3	Ensure that redwood clonal groups or "clumps" have no more than 50% of their stems greater than 8 in. dbh removed per entry.
C§8.2.3.2.4-4	Follow 1 of these practices when trees, within the first 10 ft of the watercourse channel, are removed for cable corridors: ▪ Leave the trees in the AMZ for LWD. ▪ Place trees in the active channel as per the instream LWD enhancement guidelines, if feasible.

8.2.3.2.5 Equipment exclusion

	Conservation Measures for Equipment Exclusion Small Class II AMZ
C§8.2.3.2.5-1	Exclude all equipment unless there is an allowable use. **ALLOWABLE USE** ▪ *Erosion control or restoration* MRC may use a skid trail or landing one-time-only to control erosion or conduct restoration. Upon completing operations, we will decommission the skid trail or landing. ▪ *Existing skid trails, landings, or skid trail crossings* MRC may use—only rarely (perhaps 4 times a year)—an existing skid trail, landing, or designated skid trail crossing that does not require any reconstruction, if - Alternatives would create a greater risk and magnitude of sediment delivery. - Perched material is pulled back from landings and the landings shaped to prevent rill erosion by draining them into a rocked face outlet. - Surface areas >25 ft^2 are mulched, rocked, or covered in slash compacted by a tractor. ▪ *New skid trails, landings, or skid trail crossings* MRC may construct —only rarely (perhaps once every 3 years, lessening over time) and after obtaining approval of the wildlife agencies—a new skid trail, landing, or designated skid trail crossing if - Alternatives would create a greater risk and magnitude of sediment delivery.

	Conservation Measures for Equipment Exclusion Small Class II AMZ
	- All mitigations, approved by the wildlife agencies, are fully implemented. - All trees felled for construction of these new facilities within the inner and middle bands of an AMZ have the "key piece size" logs set aside for LWD placement, either in the vicinity of the new facilities or near watercourse sections deficient in LWD. ▪ *Existing Roads* MRC may use and maintain existing roads in AMZs. ▪ *New Roads* MRC may construct new roads to watercourse approaches within an AMZ if - The road does not parallel a watercourse. - Each approach on either side of a watercourse does not exceed 200 ft. - All trees felled for construction of these new facilities in an AMZ within the inner and middle bands have the "key piece size" logs set aside for LWD placement, either in the vicinity of the new facilities or near watercourse sections deficient in LWD. MRC may construct— only rarely (perhaps once every 3 years, lessening over time) and after obtaining approval of the wildlife agencies—a road segment not associated with a crossing or an approach to a crossing if - Alternatives would create a greater risk and magnitude of sediment delivery. - All mitigations, approved by the wildlife agencies, are fully implemented. - All trees felled in an AMZ for construction of these new facilities have the "key piece size" logs set aside for LWD placement, either in the vicinity of the new facilities or near watercourse sections deficient in LWD. ▪ *Construction of watercourse crossings* MRC may use equipment to construct watercourse crossings.

8.2.3.2.6 Soil pipes[8]

	Conservation Measures for Soil Pipes Small Class II AMZ
C§8.2.3.2.6-1	Exclude equipment from the area between a Class II watercourse and a swale when there is evidence of exposed soil pipes or soil pipes transitioning into stream channels, e.g., when areas of soil over a pipe collapse or when "holes" in the floor of the swale reveal flowing sub-surface water. **NOTE** The protection should extend up the swale until there is no more evidence of soil pipe collapse.
C§8.2.3.2.6-2	Use only existing skid trails or roads.
C§8.2.3.2.6-3	Disconnect roads or skid trails hydrologically from the swale, where topographical features allow.[9]

[8] For definitions of soil pipe and swale, please refer to Chapter 16, *Glossary*.

	Conservation Measures for Soil Pipes Small Class II AMZ
C§8.2.3.2.6-4	Disperse drainage from roads or skid trails throughout the swale, if disconnecting roads or skids trails is not feasible.

8.2.3.2.7 Bare soil

	Conservation Measures for Bare Soil Small Class II AMZ
C§8.2.3.2.7-1	Treat, for erosion control, areas of exposed mineral soil which are (a) at least 100 ft^2 in size and (b) not on a running surface, with mulch, grass seed, slash, or other appropriate material; for running surfaces, see Appendix E, *Roads, Landings, and Skid Trails*.
C§8.2.3.2.7-2	Do not initiate prescribed or broadcast burning in the AMZ.

8.2.3.3 Class III AMZ

Management operations within a Class III AMZ must meet a combination of restrictions. The conservation measures for such areas are organized by these restrictions:

- AMZ band width.
- Canopy.
- Silviculture.
- Streambank stability.
- Equipment exclusion.
- Bare soil.

8.2.3.3.1 AMZ band width

	Conservation Measures for Band Widths Class III AMZ
C§8.2.3.3.1-1	Establish AMZ widths. ▪ 0-30% slope = 25 ft ▪ > 30% slope = 50 ft

8.2.3.3.2 Canopy

	Conservation Measures for Canopy Class III AMZ
C§8.2.3.3.2-1	Maintain, on average, 50% canopy over the width of the AMZ in 330 ft (100 m) sections.

[9] When water can flow continuously from a road or an adjacent ditch into a stream, the road is considered "hydrologically connected" to the stream. This connection allows run-off, sediment, and spills to drain directly into the stream. To "disconnect" a road requires diverting the water flow with either water bars or ditch relief culverts. Water bars are humps or mounds of earth or rock constructed diagonally across a road to divert the water from flowing directly into a stream. Ditch relief culverts intercept water inside a ditch and divert it across a road. While diverted water from water bars and ditch relief culverts eventually enters the stream, that water has filtered through the ground and vegetation, which removes some of the sediment along the way.

8.2.3.3.3 Silviculture

	Conservation Measures for Silviculture Class III AMZ
C§8.2.3.3.3-1	Maintain or enhance uneven-aged conditions.
C§8.2.3.3.3-2	Harvest so that trees are dispersed in a relatively uniform manner.
C§8.2.3.3.3-3	Maintain or increase conifer dominance—if necessary, by controlling hardwoods.
C§8.2.3.3.3-4	Do not sanitize or salvage LWD that is within the bankfull channel; retain all downed LWD in the AMZ unless the AMZ meets its LWD targets.
C§8.2.3.3.3-5	Leave, as a first priority, LWD previously designated as a large retention tree or wildlife tree.
C§8.2.3.3.3-6	Do not initiate prescribed burning in Class III AMZ.
C§8.2.3.3.3-7	Permit fire control lines in Class III AMZs only with concurrence of the wildlife agencies.
C§8.2.3.3.3-8	Allow salvage harvest in an AMZ only with concurrence of the wildlife agencies.
C§8.2.3.3.3-9	Allow harvest of a minimum merchantable length log from any LWD that obstructs a road.
C§8.2.3.3.3-10	Avoid damage or destruction to non-commercial vegetation beyond the minimum disturbance required for covered activities.
C§8.2.3.3.3-11	Retain all old-growth trees.

8.2.3.3.4 Streambank stability

	Conservation Measures for Streambank Stability Class III AMZ
C§8.2.3.3.4-1	Retain all trees whose trunks (a) are within 10 ft of the bankfull channel, or (b) have roots visible in the bank, or (c) provide anchor to an over-hanging bank, unless it is necessary to remove trees to create a cable corridor or thin a redwood clonal group.
C§8.2.3.3.4-2	Start the 10-ft retention zone at the landward edge of an undercut bank. **EXAMPLE** A bank is undercut by 5 ft. The retention zone will measure 10 ft from the depth of the undercut—15 ft from the edge of the bank.
C§8.2.3.3.4-3	Ensure that redwood clonal groups or “clumps” have no more than 50% of their stems > 8 in. dbh removed per entry.

8.2.3.3.5 Equipment limitation

	Conservation Measures for Equipment Limitation **Class III AMZ**
C§8.2.3.3.5-1	Adhere to the standards in Appendix E, *Roads, Landings, and Skid Trails*, and Appendix T, *Master Agreement for Timber Operations*.
C§8.2.3.3.5-2	Limit all heavy equipment unless there is an allowable use. **ALLOWABLE USE** ▪ *Existing skid trails and landings* MRC may use stable, existing skid trails and landings. We will mulch or slash skid trails and landings upon completion of operations or before the winter period, whichever comes first. ▪ *Existing roads* MRC may use and maintain existing roads. ▪ *New roads* MRC may construct new roads that do not parallel an AMZ. ▪ *New landings* MRC may construct—only rarely (perhaps once a year)—a new landing within an AMZ if - Alternatives would create a greater risk and magnitude of sediment delivery. - All mitigations, approved by the wildlife agencies, are fully implemented. - All trees felled in an AMZ for construction of these new facilities have the “key piece size” logs set aside for LWD placement, either in the vicinity of the new facilities or in the nearest Class I or Class II watercourse deficient in LWD. ▪ *New truck road crossings and skid trail crossings* MRC may construct new truck road and skid trail crossings if - Alternatives would create a greater risk and magnitude of sediment delivery. - All trees felled in an AMZ for construction of these new facilities have the “key piece size” logs set aside for LWD placement, either in the vicinity of the new facilities or in the nearest Class I or Class II watercourse deficient in LWD.

8.2.3.3.6 Bare soil

	Conservation Measures for Bare Soil **Class III AMZ**
C§8.2.3.3.6-1	Treat, for erosion control, areas of exposed mineral soil which are (a) at least 100 ft^2 in size and (b) not on a running surface, with mulch, grass seed, slash, or other appropriate material; for running surfaces, see Appendix E, *Roads, Landings, and Skid Trails*.
C§8.2.3.3.6-2	Do not initiate prescribed or broadcast burning in the AMZ.
C§8.2.3.3.6-3	Treat the running surfaces of a truck road per Appendix E, *Roads, Landings, and Skid Trails*, section E.2.5.

8.2.3.3.7 Soil pipes

	Conservation Measures for Soil Pipes Class III AMZ
C§8.2.3.3.7-1	Apply conservation measures C§8.2.3.3.7-1 through C§8.2.3.3.7-8 only when there is evidence of exposed soil pipes or soil pipes transitioning into stream channels, e.g., when areas of soil over a pipe collapse or when "holes" in the floor of the swale reveal flowing sub-surface water. **NOTE** The protection should extend up the swale until there is no more evidence of soil pipe collapse.
C§8.2.3.3.7-2	Fell trees so that they do not collapse a soil pipe, thereby prohibiting ground yarding across the collapsed soil pipe.
C§8.2.3.3.7-3	Use only existing skid trails or roads.
C§8.2.3.3.7-4	Avoid soil pipes when operating heavy equipment.
C§8.2.3.3.7-5	Cross soil pipes only at existing crossings when operating equipment.
C§8.2.3.3.7-6	Disconnect roads or skid trails hydrologically from the swale, where topographical features allow.[10]
C§8.2.3.3.7-7	Disperse drainage from roads or skid trails throughout the swale, if disconnecting roads or skids trails is not feasible.
C§8.2.3.3.7-8	Remove all transported fill upon completion of the operation.
C§8.2.3.3.7-9	Avoid equipment use in the floor of the swale, with the exception of crossing locations, even if there is no evidence of soil pipes.

8.2.3.4 AMZ restoration treatments

In some cases, a passive conservation approach will not achieve the desired level of riparian function in AMZs. To improve riparian function, MRC will use limited restoration treatments in the AMZ to (a) restore stands that are currently hardwood dominated to conifer dominance and (b) treat conifer stands that are over-stocked and stagnating. A restoration harvest, in this context, generally allows for less than 50% canopy over the AMZ. The "Alternative Conservation Measures for Restoration Treatments" indicate the exceptions (AC§8.2.3.4-1 through AC§8.2.3.4-22). The objective of the restoration treatment is to accelerate the AMZ toward improved riparian function in areas where the seral stage of climax vegetation is conifer-dominated.

Restoration treatments, as alternatives to the conservation measures for the AMZ, carry restrictions. Although this alternative treatment appears to differ from the definition of an alternative conservation measure in Chapter 7, *Planning for Conservation*, the intent of the restoration treatment is to provide more AMZ function over time than the conservation measures provide. MRC will use restoration treatments in select AMZs where hardwood dominance has superseded conifer dominance.

[10] For an explanation of hydrologically disconnecting a road, refer to the footnote for C§8.2.3.2.6-3.

Moreover, MRC plans to conduct pre- and post-treatment monitoring programs for select pilot projects in these restoration areas to assess stream temperature impacts to aquatic species (*HCP/NCCP Atlas*, MAPS 3A-3C). We will assess stream temperature regimes through our stream temperature monitoring. Using the closest monitoring location to the restoration site, we will determine in which threshold range the site falls.

ALTERNATIVE Conservation Measures for Restoration Treatments Class I, Large Class II, Small Class II, and Class III AMZ	
AMZ Restoration	
AC§8.2.3.4-1	Ensure that conservation measures for bank stability applicable within 10 ft of a bankfull channel remain in effect during a restoration treatment.
AC§8.2.3.4-2	Allow restoration treatments in coho salmon streams where temperatures are at or above the threshold and water flows July through September, with concurrence of the wildlife agencies.
AC§8.2.3.4-3	Do not use restoration treatment on inner gorge topography or within 25 ft of an inner gorge break in slope.
AC§8.2.3.4-4	Do not use restoration treatment on historically active mass wasting hazards unless operations are approved by a California Registered Geologist and meet canopy standards of 70%.
AC§8.2.3.4-5	Retain at least 50% canopy in a restoration treatment on steep streamside slopes or steep dissected topography (i.e., within TSU1, TSU2, or TSU3), unless operations are approved by a California Registered Geologist.
AC§8.2.3.4-6	Apply equipment exclusion zone (EEZ) provisions during restoration treatments except for brush crushing operations.
AC§8.2.3.4-7	Retain at least 70% canopy within the inner bands of Class I and Large Class II AMZs.
AC§8.2.3.4-8	Retain all conifers > 12 in. dbh.
AC§8.2.3.4-9	Limit the percentage of stream length that can be restored (per rolling 10-year period and per CalWater planning watershed) by the range of stream temperature thresholds for the cold-water species present in the stream length proposed for restoration or downstream of the restoration for up to ¼ mile (see Table 8-12 and Table 8-13).
AC§8.2.3.4-10	Determine stream temperature values within ¼ mile downstream of the proposed treatment site.
AC§8.2.3.4-11	Limit AMZ restoration harvests through monitoring and adaptive management. **EXAMPLE** If stream temperatures rise above the current range for target species (see Table 8-12 and M§13.5.1.1-5), MRC will adjust the amount of AMZ restoration harvest.

ALTERNATIVE Conservation Measures for Restoration Treatments Class I, Large Class II, Small Class II, and Class III AMZ	
AC§8.2.3.4-12	Phase in AMZ restoration harvests slowly with more intense monitoring in the first 5-10 years of the HCP/NCCP. **NOTE** During this initial period of intense monitoring, MRC will not conduct AMZ restoration harvests within watersheds on the 303(d) list, i.e., Navarro River, Big River, Garcia River, and South Fork Eel River.
Brush Crushing[11]	
AC§8.2.3.4-13	Perform brush crushing only on slopes < 30%.
AC§8.2.3.4-14	Raise tractor blades when brush crushing.
AC§8.2.3.4-15	Retain at least 95% of ground cover (downed brush, mulch, tree lopping, etc.).
AC§8.2.3.4-16	Do not conduct brush crushing operations within 25 ft of the bankfull channel of a Class I or Class II watercourse or within 10 ft of the bankfull channel of a Class III watercourse.
AC§8.2.3.4-17	Plant brush-crushed areas with redwood and Douglas fir, interspersed no more than 12 ft apart.
AC§8.2.3.4-18	Do not remove any overstory tree within an inner zone of the AMZ, including hardwoods, during brush-crushing operation.
AC§8.2.3.4-19	Retain conifer trees ≥ 6 in. dbh in order to create a spacing of 20 ft between trees.
AC§8.2.3.4-20	Retain conifer trees < 6 in. order to create a spacing of 15-20 ft between trees, unless their removal is required for covered activities.
AC§8.2.3.4-21	Limit brush-crushing operations to 5% of stream length per decade per CalWater planning watershed (see Table 8-13).
AC§8.2.3.4-22	Allow brush-crushing operations only within the first 40 years of the HCP/NCCP.

Table 8-12 MWMT Temperature Thresholds for Coho, Steelhead, and Coastal Tailed Frogs

Stream Temperature Thresholds for AMZ Restoration Treatments in the Plan Area			
Species	**Upper Temperature Range (C^0)**	**Middle Temperature Range (C^0)**	**Lower Temperature Range (C^0)**
coho salmon	>18	16-18	<16
steelhead	>21	17-21	<17
coastal tailed frog	>15	13-15	<13

[11] MRC proposes to use ground equipment, in special cases, to crush brush within the AMZ in order to increase conifer stocking in these zones. These areas are generally associated with hardwood-dominated or mixed conifer/hardwood stands located adjacent to a watercourse. The stands have low conifer basal areas (< 60 ft^2 per ac) and have low-to-moderate canopy levels (< 50%). MRC will not use brush crushing to convert stand types.

Table 8-13 Stream Length for AMZ Restoration Treatment in the Plan Area

Watercourse		Stream Length Limit by Stream Temperature Threshold Per 10-year Rolling Period and Per CalWater Planning Watershed		
		Upper Temperature Range	**Middle Temperature Range**	**Lower Temperature Range**
Class I	Inner Band	No treatment allowed	5%	10%
	Middle Band	5%	10%	10%
	Outer Band	10%	15%	15%
Large Class II	Inner Band	No treatment allowed	5%	10%
	Middle Band	5%	10%	10%
	Outer Band	10%	15%	15%
Small Class II		15%	10%	15%
Class III		15%	15%	15%

8.2.3.5 Wetlands, wet meadows, wet areas, seeps, and springs

8.2.3.5.1 Wetlands, wet meadows, and wet areas

DEFINITION

Wetlands, wet meadows, and wet areas are natural areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to develop hydric soils and to support, with adequate sun light, a prevalence of hydrophytic vegetation.

Wetlands generally include swamps, marshes, bogs, and similar areas. Wetland areas include tidal or estuarine wetlands which may be highly saline. The presence of hydric soils, aquatic animals, or hydrophilic plants may also assist in defining wetland areas.

	Conservation Measures for Wetlands, Wet Areas, and Wet Meadows
C§8.2.3.5.1-1	Maintain a 25-ft EEZ (excluding existing roads) around wetlands, wet meadows, and wet areas whose surface area is > 10 ft^2 and < 50 ft^2.
C§8.2.3.5.1-2	Maintain a 50-ft EEZ (excluding existing roads) around wetlands, wet meadows, and wet areas that are more than 50 ft^2 in surface area. **NOTE** MRC must obtain approval of our aquatic biologist before equipment can enter the EEZ of a wet area, wetland, or a wet meadow, making them a potential equipment limitation zone (ELZ). C§10.2.2.3-2, C§10.2.2.3-3, C§10.2.2.3-8, C§10.2.3.3-1, and C§10.2.3.3-2 describe the survey methods and criteria for entering the EEZ.
C§8.2.3.5.1-3	Avoid artificial wetlands, wet areas, and wet meadows created by forest management, except for the use of existing roads or where alternate routes would result in more habitat degradation.
C§8.2.3.5.1-4	Retain within the EEZ at least 75 ft^2 of basal area or at least 50% of the pre-harvest basal area, whichever is greater.
C§8.2.3.5.1-5	Fell trees away from the area, unless this creates a safety hazard.
C§8.2.3.5.1-6	Leave trees in place that were felled to remediate safety concerns.

	Conservation Measures for Wetlands, Wet Areas, and Wet Meadows
C§8.2.3.5.1-7	Retain old growth trees.
C§8.2.3.5.1-8	Do not sanitize or salvage harvest.
C§8.2.3.5.1-9	Retain LWD.
C§8.2.3.5.1-10	Survey a water drafting site for covered species prior to its development and apply the conservation measures for the covered species present.
C§8.2.3.5.1-11	Follow water drafting guidelines specified in C§10.2.2.3-4 and Appendix E (section E.7, *Standards for Water Drafting)*.
C§8.2.3.5.1-12	Protect covered wetland plants (see Chapter 11, *Conservation Measures for Rare Plants)*.

8.2.3.5.2 Seeps and springs

DEFINITION Seeps and springs are groundwater discharge that slowly oozes to the surface of the ground or is visibly flowing from the ground.

Springs are locations where water emerges from the ground and flow is evident. Generally seeps are non-flowing water emerging from the ground. Seeps and springs often have hydrophytes (plants adapted for life in water), wet soil, and standing water throughout most of the year.

MRC will use similar management measures for both seeps and springs, due to the variability of delineation. A seep one portion of the year, for example, may be a spring at another time.

	Conservation Measures for Seeps and Springs
C§8.2.3.5.2-1	Protect seeps or springs within Class I or Class II watercourses of AMZs.
C§8.2.3.5.2-2	Extend the AMZ boundary 50 ft beyond a seep or spring, if the seep or spring is on, near, or draining into the AMZ boundary.
C§8.2.3.5.2-3	Apply a 50-ft EEZ (excluding existing roads) and a 50% canopy retention requirement to seeps or springs that do not drain into a defined watercourse and are unable to deliver sediment to higher order streams. **NOTE** MRC will require a biological consultation with an MRC biologist before equipment can enter the EEZ of a seep or spring, making them a potential ELZ. C§10.2.2.3-2, C§10.2.2.3-3, C§10.2.2.3-8, C§10.2.3.3-1, and C§10.2.3.3-2 describe the survey methods and criteria for entering the EEZ.
C§8.2.3.5.2-4	Avoid artificial wetlands, wet areas, and wet meadows created by forest management, except for the use of existing roads or where alternate routes would result in more habitat degradation.
C§8.2.3.5.2-5	Fell trees away from seeps or springs, unless this creates a safety hazard.

	Conservation Measures for Seeps and Springs
C§8.2.3.5.2-6	Leave felled trees in place that were cut to remediate safety concerns.
C§8.2.3.5.2-7	Retain within the EEZ at least 75 ft^2 of basal area or at least 50% of the pre-harvest basal area, whichever is greater.
C§8.2.3.5.2-8	Retain all old-growth trees.
C§8.2.3.5.2-9	Do not sanitize or salvage harvest.
C§8.2.3.5.2-10	Retain LWD.
C§8.2.3.5.2-11	Survey a new or un-surveyed water drafting site for covered species prior to use and apply the conservation measures relevant to the covered species present.
C§8.2.3.5.2-12	Follow water drafting guidelines specified in C§10.2.2.3-4 and Appendix E (section E.7, *Standards for Water Drafting)*.

8.2.3.6 LWD placement

MRC will place LWD in Class I watercourses to improve stream habitat conditions. Our initial focus will be coho "core" watersheds (see section 8.3.3.2.2). Adaptive management will play a role in improving the placement process. MRC will determine locations for LWD placement through watershed analysis. Streams with high LWD demand and channel responsiveness have highest priority. MRC will notify the wildlife agencies about the placement of LWD through a site-specific plan. However, MRC may place individual trees, felled for a cable corridor or safety hazard, in watercourses without a site-specific plan, as long as we notify the wildlife agencies about such placements in an annual report.

Many of the riparian areas adjacent to watercourses that have high demand for LWD consist of stands that are below desirable levels for basal area and riparian canopy cover. They may not reach a harvest trigger for up to 30 or 40 years. MRC will develop, in conjunction with the wildlife agencies, a plan to address LWD demand in these areas, particularly in coho "core" watersheds.

	Conservation Measures for LWD Placement
C§8.2.3.6-1	Do not blade a trail to a tree.
C§8.2.3.6-2	Use existing roads or skid trails rather than building roads or skid trails.
C§8.2.3.6-3	Ensure that there is minimal soil disturbance in placing LWD, including the stump, into a watercourse.
C§8.2.3.6-4	Push standing trees into a watercourse with heavy equipment, as long as rootwads remain attached to LWD.
C§8.2.3.6-5	Ensure that the diameter of any wood placed as LWD in a watercourse is at least 80% of the key piece diameter, if a rootwad is attached, or meets key piece size requirements for diameter and length, if a rootwad is not attached.

	Conservation Measures for LWD Placement
C§8.2.3.6-6	Ensure that LWD, with rootwad attached, is at least as long as the bankfull channel width or 1.5 times the bankfull channel width, if there is no rootwad.
C§8.2.3.6-7	Place a rootwad within a stream channel provided a rootwad exceeds the volume standard for *key pieces*.
C§8.2.3.6-8	Do not exceed minimum numbers for “key pieces” by more than 300% when placing LWD “artificially” in order to moderate the amount of LWD in stream channels (see Appendix G, G.3.3.1, *General methods for LWD recruitment*).

Bankfull Width (ft)	Minimum Number of Key LWD Pieces		
	Per 328 ft	Per 1000 ft	Per Mile
<15	6.6	20	106
15-35	4.9	15	79
35-45	3.9	12	63
>45	3.3	10	53

C§8.2.3.6-9	Do not use downed wood from the AMZ unless the AMZ exceeds its target for LWD.
C§8.2.3.6-10	Permit the placement as LWD of 1 tree designated for large tree retention within a 330 ft segment of an AMZ, if the watercourse does not meet the target for key piece loading.
C§8.2.3.6-11	Fell trees into a stream channel provided the length of the tree segment that will interact with the stream channel is at least 1.5 times the width of the bankfull channel. **NOTE** This primarily refers to trees cut for a cable corridor.
C§8.2.3.6-12	Retain foliage from trees felled into a stream channel.
C§8.2.3.6-13	Do not place LWD pieces in one spot (i.e., within 100 ft of each other) without a site-specific plan developed by an MRC fisheries biologist or hydrologist; notify the wildlife agencies in an annual report of the LWD placement.
C§8.2.3.6-14	Situate LWD to maximize habitat benefit and minimize adverse effects.
C§8.2.3.6-15	Follow the guidelines in the CDFG *Salmonid Restoration Manual* when designing specific structures; otherwise ensure stability of LWD placement by following size requirements for key pieces (see Appendix G, G.3.3.1, *General methods for LWD recruitment*) and wedging LWD between riparian trees when possible.
C§8.2.3.6-16	Add LWD only during the course of PTHP activities, unless there is a site-specific plan.
C§8.2.3.6-17	Tag and mark LWD added to stream channels to allow MRC and the wildlife agencies to track it over time through instream monitoring programs.

	Conservation Measures for LWD Placement
C§8.2.3.6-18	Develop within the first 5 years of the HCP/NCCP and implement within the first 20 years of the HCP/NCCP an LWD placement plan for coho "core" watersheds. **NOTE** These planning watersheds, and in certain cases, sub-watersheds are: East Branch North Fork Big River; Russell Brook; Ramone Creek; a section of South Daugherty Creek, from the confluence of Gates Creek and Daugherty Creek downstream to the MRC property line; Middle Albion River; South Fork Albion River; John Smith Creek; Little North Fork Navarro River; Cook Creek; Lower South Branch Navarro River; Lower Navarro Drainages (Marsh, Flume, and Murray Gulches); Cottaneva Creek; Hayworth Creek; and the South Fork Garcia River. Appendix Z (section Z.1*"Selecting Coho Core Watersheds for Road Restoration*" and Table Z-1 MRC Coho Core Areas), describes the coho "core" watersheds in more detail. Section 8.3.3.2.2 outlines MRC plans for controllable erosion in these areas. The elevated LWD implementation schedule will, at a minimum, ensure that the watersheds contained within Table S-11 (*Future LWD Targets within the Plan Area by Planning Watershed*) will meet half of their target for "% of Segments with Low or Moderate Demand for LWD" by Year 10 of the HCP/NCCP and meet their full target by Year 20. Since the target date is actually Year 80, the coho "core' watersheds will cut their timeline by 75%.
C§8.2.3.6-19	Conduct LWD placement in coho "core" watersheds without equipment access during the first entry into the area under the HCP/NCCP.
C§8.2.3.6-20	Reduce, if necessary, the basal area harvest retention standards by the amount of basal area felled for LWD placement while still maintaining minimum shade requirements.

8.2.4 Rationale

8.2.4.1 Riparian function by watercourse type

Streams transition from headwater Class III intermittent streams supporting no aquatic life downstream to Class I perennial streams supporting abundant aquatic life—Chinook and coho salmon, steelhead, coastal tailed frog, and red-legged frog. Recognizing the interconnectivity of riparian functions from headwaters to downstream is essential in proposing riparian conservation measures. Riparian corridors represent transition zones for the land-water interface; they support both physical and biological functions for stream ecosystems. Functions of the riparian zone have both temporal and spatial scales that are interconnected to maintain equilibrium within aquatic ecosystems (Gregory et al. 1991). From the headwaters to reaches downstream, these functions proliferate with increasing stream class. Riparian processes initiated in the headwaters are transferred downstream and directly affect water and habitat parameters, as well as aquatic organisms using various reaches (Vannote et al. 1980, Naiman et al. 1992).

MRC classifies watercourses based on species use and processes occurring within the watercourses. Riparian functions change from small headwater channels downstream to larger streams and rivers, as do species use. Within the AMZ, MRC proposes different levels of protection based on the classification of each watercourse. For each of these watercourse classes, the contribution of riparian vegetation to the processes and functions that provide habitat for covered species varies. Riparian functions include, but are not limited to, woody debris recruitment; shade retention and water temperature regulation; nutrient and organic matter cycling; microclimate regulation; streambank stability enhancement; and prevention of surface erosion (Swanson et al. 1982, FEMAT 1993, Spence et al. 1996).

8.2.4.2 AMZ widths

The width of an AMZ is based on (1) likelihood of LWD recruitment; (2) potential for sediment delivery from streamside disturbances; and (3) occurrence of covered aquatic species in different watercourse types.

MRC measures the width of an AMZ from the edge of a bankfull channel. Bankfull discharge is the channel-forming flow that transports the bulk of available sediment over time (Wolman and Miller 1960). The presence of a floodplain at the elevation of incipient flooding easily delineates the bankfull stage. However, a trained observer can also estimate it from (a) deposits of fine sediments such as sand or silt at the active scour mark, (b) a break in stream bank slope, and (c) perennial vegetation limit (Flosi et al. 1998). In the absence of a well-defined floodplain surface, other indicators are useful. In any case, the observer should always use parallel lines of evidence (Kondolf et al. 2003).

MRC proposes different levels of protection based on watercourse classification, riparian functions, and processes important for covered species and their habitats. Class I and Large Class II watercourses provide habitat for nearly all of the covered species. Covered species use Small Class II watercourses less often because they lack year-round surface flow and are smaller in size; they do not use Class III watercourses at all.

As streamside slopes increase, the influence of gravity increases the probability that streamside trees will fall toward the stream and sediment will be delivered. Other trees, although farther from the stream, are still likely to provide stream shade. Because slope gradient affects these riparian processes, AMZ width is based on slope gradients adjacent to a watercourse. Width of the AMZ will vary according to 3 slope classes (i.e., 0-30%, 30-50%, >50%),[12] with higher AMZ widths for steeper streamside topography within each class of watercourse.

The height of 1 site-potential redwood tree adjusted to slope distance influences the width of an AMZ for Class I, Large Class II, and Small Class II watercourses. Trees within this distance from a stream provide approximately 90-100% of LWD recruitment from streamside stands (McDade et. al., 1990; Murphy and Koski, 1989; Reid and Hilton, 1998; Van Sickle and Gregory, 1990). On the other hand, LWD recruited through mass wasting events is often from areas farther away; our mass wasting conservation measures allow for large tree retention to provide for this source. The majority of the plan area has trees that are Site Class III. This should yield a redwood tree that ranges in height from 130-150 ft in 100 years (Lindquist and Palley 1963).

Widths of AMZs for Class I and Large Class II watercourses range from 100-190 ft. The maximum AMZ width of 190-ft slope distance is based on the height of a Site Class III redwood tree (150 ft) adjusted to slope distance for an 80% slope gradient. We assume this represents the upper range of slope gradients adjacent to watercourses in the coast range. The 130 and 150 ft AMZ widths represent the range in height of Site Class III redwood trees. A width of 100 ft represents approximately 75% of a Site Class III redwood tree height. Approximately 75% of LWD recruitment occurs within 75% of 1 tree height (slope distance) of the stream channel (Reid and Hilton 1998).

[12] To be consistent with regulations, we use slope classes from the California Forest Practice Rules (circa 2003).

Small Class II and Class III watercourses have reduced AMZ widths because smaller LWD is sufficient for smaller stream channels; in addition, there is less need for streamside shade to cool water temperature because of the lack of year-round water flow.

8.2.4.3 Differentiating smaller watercourses

In differentiating Small and Large Class II watercourses, MRC recognizes that riparian functions vary by watercourse size. The size of a Class II watercourse influences the likelihood of surface water flow in summer and the size and amount of LWD for instream habitat. Therefore, our riparian conservation measures reflect these differences. MRC differentiates Small and Large Class II watercourses by watershed size, which is easily defined and not subject to interpretation or annual precipitation fluctuations. We will consider watersheds with breeding coastal tailed frogs present as Large Class II regardless of the size of the drainage area.

In steep dissected terrain, as found in the plan area within the California Coast Range, ground water aquifers along the stream channel are topographically constrained to the area near the channel and have limited capacity for water storage (Hewlett, 1969). Across the plan area, there is rarely significant summer precipitation to recharge ground water. The storage capacity for ground water accumulates as watershed size increases. This also increases the likelihood of surface water flow in summer. The watershed size likely to provide increased surface water flow varies by (1) the amount and timing of precipitation in an area; (2) localized soil and geology conditions; (3) depth of alluvial material in the channel; and (4) storage capacity and transmissibility of the near-stream aquifer. Until MRC can define this watershed size more precisely with post-harvest monitoring, we will use 100 ac as the dividing line between Small and Large Class II watercourses. Within the plan area, a watershed size less than 100 ac seldom has surface water flow year-round. In the rare situations that surface flow does exist year-round, we assume the proportion of the water downstream is small.

Generally, as stream channel size decreases, vegetation close to the stream provides a relatively higher proportion of riparian functions (ODF 2001). In the smallest streams, the majority of shade comes from under-story vegetation along the bank. Streams less than 6 ft in bankfull-width meet or exceed stream shade targets because of shrub and grass vegetation along the banks (ODF 2001). Using the bankfull regional curve for the San Francisco region (Rosgen 1994), 100 ac corresponds to a bankfull width of approximately 8 ft. This suggests that under-story vegetation will provide summer shade on small watercourses.

Large streams require large sizes of LWD that can remain stable in the channel (Bilby and Ward 1989). Smaller LWD, however, can create habitat features in small channels (ODF 2001, Bilby and Ward 1989), where the cross-sectional area of a stream is smaller and stream power lower. Furthermore, LWD remains in small channels for a longer period of time.

8.2.4.4 Flood-prone and channel migration zones

The majority of streams and rivers that flow through the plan area are within narrow canyons. This results in little floodplain development or stream channel migration. The relatively young age of the Coast Range combined with high uplift rates create frequent narrow canyons. Floodplains along stream channels tend to be small and infrequent, with few exceptions. Further, because the rivers and streams are within narrow and confined canyons, there is little opportunity for migration of stream or river channels through alluvial deposits.

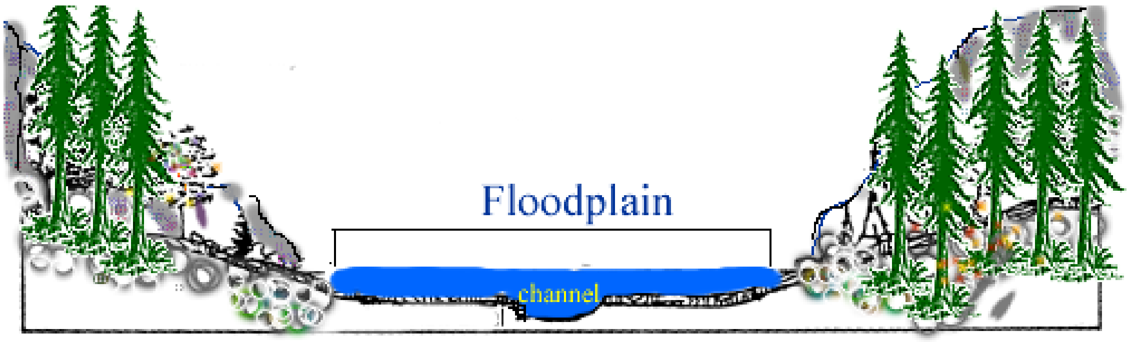


Figure 8-8 Illustration of a Channel and Floodplain

Riparian or streamside vegetation affects channel morphology through a number of mechanisms (Swanson et al. 1982, Sedell and Beschta 1991). Vegetation increases hydraulic resistance and friction. This reduces flow velocity and erosion at high discharges. The root systems of vegetation protect the soil of banks and floodplains from erosion. Plus roots contribute organic matter, which improves soil aggregation. Riparian root systems encourage bank stability and reduce the incidence of bank failure during flood recession. Surface root mats promote the formation of undercut banks, which provide important shelter for fish and amphibians.

The required width of riparian buffers to protect hydraulic functions and bank stability will vary. The effects of vegetation on flow hydraulics depend on flood stage and flood frequency. Where banks are steep and the channel is confined (the most common channel morphology in the plan area), a riparian buffer width of 25-50 ft (7.6–15.2 m) will typically extend beyond the 100-year flood-prone area. This is within the influence of the AMZ inner band for Class I and Large Class II watercourses. Where a wide floodplain is present (more likely on Class I than on Class II or Class III streams), the effects of large floods may extend beyond the inner band, but should be encompassed by the middle band. A vegetated buffer in the inner band, however, would normally maintain most of the hydraulic functions of riparian vegetation in the plan area. This is due to the confined nature of the channels and canyons on our property. MRC has mapped areas where the channel is not confined and the floodplains are wide. In these areas, MRC provides wider AMZ protections and increased basal area retention requirements.

Channel migration zones are infrequent within the plan area. Those that do occur are the result of one or more avulsion channels formed within the flood-prone areas of streams or rivers. During periods of high flow, water occupies these avulsion channels. Over time the active channel may migrate to these avulsion channels. The migration typically will be in response to blockage of the active channel from LWD dams, large mass wasting deposits, or persistent erosion of stream banks. These channel migration areas will require increased riparian protections. If the active channel migrates, new sources of LWD, shade, and other riparian processes need to be provided. Furthermore, the avulsion channels within the channel migration zone often provide refuge for aquatic organisms during high flow events. These channel migration zones are infrequent. MRC has mapped them and provides additional conservation measures there.

The majority of riparian function is provided in the inner and middle bands of the AMZ; these bands encompass the flood-prone or channel migration zone. If the edge of the flood-prone or channel migration zone is wider than the edge of the middle band, MRC will extend the AMZ to encompass the flood-prone or channel migration zone. MRC has mapped the areas where flood-prone or channel migration zones exist within our land and included these maps in our *HCP/NCCP Atlas* (MAPS 3A-3C). These are typically areas with alluvial deposition and high moisture content and are very productive tree-growing sites.

Flood-prone and channel migration areas require the highest basal area retention within the AMZ. Higher basal area will provide for larger and greater numbers of trees. This, in turn, will (a) ensure integrity of the riparian function in the flood-prone environment; (b) serve as a source of future shade should the channel migrate; and (c) provide a good source of LWD across the flood-prone or channel migration zone.

8.2.4.5 Wetlands, wet meadows, and wet areas

Wetlands, which are often adjacent to or contain red-legged frog breeding habitat, provide good foraging habitat for red-legged frogs due to their high moisture and productivity. These habitats are also important breeding, foraging, and hydrating habitats for other native amphibians. Frogs use slow moving, deep, cold water with surrounding or submerged aquatic vegetation, such as cattails and bulrushes. Wetlands, wet meadows, and wet areas generally have grasses, forbs, and aquatic vegetation as ground cover, although some areas dominated by grasses and forbs are not wetlands. There are very few (if any) trees in these areas; thus the potential impacts of timber harvesting are minimal.

MRC will protect wetlands, wet areas, and wet meadows by

- Minimizing disturbance to breeding or foraging habitat of red-legged frogs.
- Preventing soil compaction or alteration.
- Maintaining the natural hydrologic function.

8.2.4.6 Seeps and springs

Seeps and springs provide potential foraging or hydrating sites for red-legged frogs, coastal tailed frogs, and other amphibians, as well as habitat for southern torrent salamanders. The southern torrent salamander requires cold water with minimal substrate embeddedness.

MRC will protect seeps and springs by

- Maintaining cool water temperatures.
- Minimizing sediment input and soil compaction associated with equipment.
- Minimizing disturbances from tree felling.
- Maintaining the natural hydrologic function.

8.2.4.7 LWD recruitment processes

LWD is widely recognized as an important part of the aquatic ecosystem (Swanson and Lienkaemper 1978, Bilby and Likens 1980, Bisson et. al. 1987). It is also a vital component of quality habitat for aquatic organisms (Bisson et. al. 1987). LWD influences channel morphology by

- Dissipating stream energy.
- Controlling grade along the channel’s length.
- Increasing channel roughness.
- Storing and sorting sediment and organic matter.
- Increasing the complexity and cover of stream, floodplain, and riparian habitats.

LWD provides an organic energy source for aquatic organisms; controls the routing of sediment through stream systems; and provides structure to the streambed and banks (Swanson and Lienkaemper 1978, Bilby and Likens 1980, Naiman et al. 2000).

In general, LWD is at low levels in the streams throughout the plan area. Forest managers have harvested streamside trees that could have delivered LWD to watercourses; they have salvaged downed LWD from watercourses or adjacent banks. In the name of stream habitat enhancement and fish passage improvement, CDFG and its contractors removed LWD from stream channels across what is now MRC land. These activities no longer continue, but their effect on instream LWD levels will be seen for a long time.

Most of the recruitment of LWD to stream channels comes from windthrow, bank erosion, and mass wasting events (O'Connor and Ziemer 1989, Surfleet and Ziemer 1996, May 2002, Benda et al. 2002). In a mature second-growth redwood and Douglas-fir forest in Caspar Creek, windthrow and bank erosion were the primary mechanisms for LWD recruitment, with mass wasting providing a smaller portion of the instream LWD (O'Connor and Ziemer 1989; Surfleet and Ziemer 1996). Windthrow increased after logging and during intense wind storms, accounting for about 75% of the LWD volume in North Fork Caspar Creek and about 50% in South Fork; significantly, North Fork was 50% clearcut in the early 1990s and South Fork had partial harvest in the early 1970s (Keppeler 1996).

Areas adjacent to clearcuts experienced significantly more LWD recruitment to the channel than other areas. LWD levels in the South Fork of Caspar Creek were lower than the North Fork due to stream clearing of LWD in the early 1970s. LWD in South Fork Caspar Creek was still at low levels 20 years after clearing (Surfleet and Ziemer 1996).

Though mass wasting did not deliver large amounts of LWD to stream channels in Caspar Creek, many areas prone to debris slides and debris flows can deliver very significant amounts of LWD (Benda et al. 2002, May 2002). A debris flow may transport wood and sediment stored on hillslopes to first-to-third order channels. These episodic disturbances play a major role in delivering wood and sediment to stream networks in steep mountainous terrain (Keller and Swanson 1979, Swanson et al. 1982, Benda and Dunne 1997, all as cited in May 2002).

Low-order streams are especially susceptible to large mass wasting events due to their proximity to steep slopes and their narrow channel width and high gradient (Swanson et al. 1982, Benda and Dunne 1997, Naiman et al. 1992, all as cited in May 2002). In such streams, sediment and wood are rarely transported by chronic processes (Swanson et al. 1982), but are stored for longer periods of time. The majority of wood in a debris slide appears to be remobilized wood that was previously stored in low-order streams, indicating a critical link between hillslope and fluvial processes in mountain streams, where episodic events redistribute material that has been stored in small streams for decades to centuries (May 2002).

LWD recruitment from mass wasting processes in redwood ecosystems may be a less important mechanism in larger order streams; it is mainly associated with streamside events. In the Garcia River, about 1% of LWD recruitment occurred by mass wasting (O'Connor Environmental Inc. 2000), as compared to 4% in North Fork Caspar Creek and 11% in South Fork (O'Connor and Ziemer 1989, Surfleet and Ziemer 1996). In Freshwater Creek, only about 3% of LWD in mainstem stream channels comes from landslides (PALCO 2001). Of this 3% contribution, a majority comes from small streamside landslides. In old-growth stream systems, recruitment of LWD from mass wasting processes varies depending on stream gradient, streamside slope, and confinement. For example, in higher gradient Little Lost Man Creek, landslides recruit 40–60% of the volume of LWD; in lower gradient Prairie Creek, there is little or no recruitment from landslides (Benda et al. 2002).

Recruitment of LWD into stream channels can be both frequent chronic inputs and infrequent episodic inputs (Bisson et al. 1987) that create both temporal and spatial variability in LWD abundance. Chronic inputs generally consist of natural tree mortality due to disease or insects, windthrow, and bank undercutting, while episodic inputs result from large-scale insect or disease epidemics, large blowdown events, debris flows, and bank erosion from major floods (Keller and Swanson 1979, Bisson et al. 1987, O'Connor and Ziemer 1989, Keppeler 1996, Surfleet and Ziemer 1996). Further, the movement of LWD in the stream channel network is governed by large flood events that occur infrequently.

Debris loading is generally highest in low-order stream channels (Keller and Swanson 1979, Robison and Beschta 1990a, Montgomery et al. 1995 as cited in Lassettre and Harris 2001). Distribution of pieces within these channels is usually characterized by frequent randomly distributed individual pieces and small jams, since small channels do not have sufficient stream flow to transport LWD. Logs can remain stationary for long periods of time but through time will decay or transport via mass wasting processes (May 2002, Keller et al. 1981).

Channel response to changes in LWD depends upon the role of wood on sediment storage and pool formation; these effects vary through the stream channel. In steep landscapes, source reaches are transport-limited and store sediment; a decrease in supply of LWD can accelerate sediment transport and decrease sediment storage (Bilby 1981, Nakamura and Swanson 1993, Montgomery and Buffington 1993). Further downstream, transport reaches are high-gradient channels with limited supplies of sediment; they convey sediment inputs downstream to response reaches.[13]

MRC will maintain high basal areas of conifer trees at streamside and permanently retain the largest shade trees to ensure recruitment of LWD to stream channels. Section 8.2.4.9 provides some projections of AMZ characteristics over time in the context of instream LWD levels measured in Prairie Creek (Keller et al. 1995). Research indicates that mass wasting deposits some LWD into streams, although the amount is unknown (see section 8.2.4.8). MRC guidelines for tree retention provide for large trees upslope which potentially could enter into streams. In areas of high mass wasting hazard (i.e., TSU1, TSU2, and TSU3), MRC will retain trees to provide LWD input in case of slope stability. Retention of canopy (typically 50%) and of at least 15 ft^2 of conifer trees ≥18 in. dbh per acre will ensure large trees are available to become LWD for streams. The Forest Practice Rules originally developed the "8-18" standard for seed trees. Over the years, the Board of Forestry has modified this rule to create a standard for basal area retention of trees exceeding 18 in. dbh. Wherever the term "8-18" appears in our HCP/NCCP, it signifies 15 ft^2 of basal area of conifers with a dbh of 18 or more inches.

Our level of harvest is based on both economic and regulatory realities. Our decision to harvest more or less, depending on landscape planning and log prices, carries certain benefits and constraints. Economical harvests, for example, allow MRC to do road restoration work that typically occurs during harvesting—clearly a benefit not only for ongoing transportation and hauling but for sediment and erosion control as well. In an effort to maintain economical harvest levels, MRC may at times be unable to follow the "8-18" standard. This deviation from the standard will only apply in select areas that require prescriptions for either seed tree removal or shelterwood removal. Moreover, such deviation will only occur within the first 20 years of our HCP/NCCP and only once within a stand. All other silvicutural prescriptions, apart from seed tree removal and shelterwood removal, must maintain the "8-18" standard. This means that if the requisite basal area does not exist in the pre-harvest stand, MRC cannot harvest trees with a dbh 18 in. or greater.

[13] Refer to Chapter 16, *Glossary*, for more information on source, transport, and response reaches.

8.2.4.8 LWD recruitment rates

Recruitment rates of LWD are variable and depend on health of the stand; age of the stand; harvest history of the stand; position of the stand relative to a stream; stream size; and environmental conditions, such as windstorms and floods. The conservation measures for large tree retention, specifically designed to provide LWD to streams, are C§8.2.3.1.4-1 through C§8.2.3.1.4-5.

Forest harvest practices in riparian areas, including clear-cutting and harvesting old-growth, can decrease the availability of LWD for recruitment. The extent to which windthrow, bank erosion, and mass wasting add LWD to streams depends on several factors, including stand health, stand age, slope, and forest practices (Benda et al. 2002). For example, recruitment of LWD by windthrow is higher if trees fall on a steep slope (Hairston-Stang and Adams 1998). Streamside landslides recruit a high volume of LWD in Little Lost Man Creek (Benda et al. 2002), whereas in Prairie Creek LWD is recruited primarily by bank erosion processes (Benda et al. 2002).

Using clearcut practices can eliminate LWD recruitment up to 100 years (Beechie 1998). Old-growth stands, compared to younger stands, also produce more and larger LWD pieces that are less susceptible to decay and remain in the watershed system for a longer period of time (O'Connor Environmental Inc. 2000, May 2002, May and Gresswell 2003). Benda et al. (2002) show that, in northern California, diameters of LWD were greater in streams surrounded by old-growth redwood forests. Recruitment from forest mortality, however, was lower in old-growth forests than in second-growth forests (2.5 m^3/km/year and 4.0 m^3/km/year, respectively). Based on representative trees per acre and volume per acre estimates, mortality is higher in second growth stands than in old-growth stands because of increased competition for light, water, and nutrients (0.9% and 0.04% per year, respectively).

In North Fork Caspar Creek, LWD from Douglas fir, redwood, and other mixed conifer and hardwood stands was recruited, after logging, at a rate of 5.3 m^3/ha/yr. Most LWD was recruited by windthrow and to a lesser extent bank erosion and logging debris (O'Connor and Ziemer 1989, Surfleet and Ziemer 1996). In the Garcia River, LWD was recruited at an average rate of 3.67 m^3/ha/yr (O'Connor Environmental Inc. 2000). Redwood LWD recruited at an average of 4 m^3/ha/yr (0.21-23.3 m^3/ha/yr).

Redwood LWD recruitment from mortality is generally low in old-growth forests, with higher rates in second growth forests; however, researchers could only identify the sources for 27% of the volume of recruited wood in old-growth sites (Benda et al. 2002). The recruitment processes associated with second-growth sites include logging debris from past timber harvests and higher mortality rates compared to old-growth forest sites (Benda et al. 2002). The mean proportion of LWD volume recruited in second growth sites averaged 21% (0.3-9.7 m^3/ha/yr [mean 6.3]) due to mortality; 18% (0.1-11.8 m^3/ha/yr [mean 4.8]) due to bank erosion; 13% (0-45 m^3/ha/yr [mean 4.4]) due to landsliding; and 50% due to logging (Benda 2002). LWD from old-growth sources was recruited at different rates and varied by watershed (Prairie Creek vs. Little Lost Man Creek). Mortality accounted for 60% of the LWD recruitment in Prairie Creek and only 20% in Little Lost Man; bank erosion accounted for 40% and 22% and landsliding for 0% and 58%, respectively (Benda et al. 2002).

8.2.4.9 Instream LWD levels by streamside tree density

The goal of this analysis was to determine how many trees needed to be retained long-term to meet instream LWD recruitment objectives in redwood-dominated forests. The analysis focused on published empirical relations developed for recruitment processes in old-growth and second-growth forests in coastal northwestern California.

Over the past decade, minimum buffer widths required for LWD recruitment to fish-bearing streams have ranged from less than 1 to 2 site-potential tree heights (FEMAT 1993, Kondolf et al. 1996, Spence et al. 1996). Trees located farther than 1 site potential tree height from the stream, however, are less likely to contribute wood to the channel unless they occur on wide valley bottoms that are periodically occupied by debris flows or are transported to the channel by inner gorge mass wasting (Reid and Hilton 1998). This analysis evaluated long-term instream LWD loading from leave-tree recruitment zones of variable width within 1 site-potential tree height from the channel. For the purpose of this analysis, a distinction is made between a *riparian buffer* and a *LWD recruitment zone* within the buffer where a specified density of mature trees is left for the purposes of long-term LWD recruitment.

The total potential recruitment zone was defined in this analysis as that portion of the valley floor and adjacent slopes within 1 site-potential tree height from the channel bank. This analysis considered three recruitment widths: 50 ft (15.2 m), 100 ft (30.5 m), and 150 ft (45.7 m). Recruitment widths are based on slope distance from the channel bank. Each recruitment area was calculated by multiplying the specified width by a constant channel length of 328 ft (100 m).

Keller et al. (1995) developed a functional equation relating density of old-growth redwood trees growing within 164 ft (50 m) of either streambank to LWD loading (m^3/m^2) in adjacent channel segments of Prairie Creek. Old-growth redwood trees dominated total in-channel LWD loading due to their large size and resistance to decay. In this analysis, LWD loading rates (m^3/m^2) based on stand densities were initially determined using a power function ($y=0.00006x^{2.019}$, $r^2=0.82$) fit to data from Keller et al. (1995) as shown in Figure 8-9. The relation between stand density and LWD loading is valid given the following *assumptions*:

1. The 164 ft (50 m) wide zone in which Keller et al. (1995) measured tree density encompassed the width of the recruitment zone.
2. Stand densities measured by Keller et al. (1995) encompass the range of stand densities found in redwood-dominated forests.
3. Trees within the 164 ft (50 m) wide recruitment zone are equally distributed and recruitment processes are uniform.

The cumulative percent of LWD recruitment from 50-ft, 100-ft, and 150-ft-wide recruitment zones was determined using three empirical LWD source-distance curves generated for second-growth redwood forests in the Caspar Creek basin (Reid and Hilton 1998, as cited in Peters 2000) Figure 8-10 illustrates these source distance curves.[14] Recruitment widths are based on the percent of 1 site-potential redwood tree height. A site-potential redwood tree height of 213 ft (65 m) is based on an average tree height of 164 ft (50 m) at 100 years for Site Class II (CDF 2001) multiplied by 1.2 to correct for the height of a mature tree at 200 years. We assumed for this analysis that tree density, recruitment processes, and cumulative recruitment in Caspar Creek forests where the three empirical relations were generated are similar to those of the Prairie Creek basin where the stand density to LWD loading relation was developed.

14 Site names in Figure 8-10 do not correspond to site names in Reid and Hilton (1998); they are site names given by Peters (2000).

Although Caspar Creek and Prairie Creek have physically similar LWD input factors, such as channel slope, width, and gravel substrate, Prairie Creek contains a higher frequency of large diameter conifer trees located near the channel and higher LWD loading (Tally 1980, Keller et al. 1981, Napolitano 1998). Old growth conifer stands may contribute LWD to streams from greater distances than stands with younger, shorter trees (McDade et al. 1990). Stands comprised predominantly of smaller, second-growth conifers and riparian hardwoods may, therefore, lead to a much different pattern and density of LWD recruitment than that found in streams draining old growth forests. Napolitano (1998), for example, reports 26-52 large redwood trees per hectare and 49-268 kg of wood per square meter along Little Lost Man Creek (tributary to Prairie Creek); that is 2 to 7 times more than in North Fork Caspar Creek. Furthermore, stream channels in Prairie Creek are largely undisturbed, while stream channels in Caspar Creek were used extensively for transporting logs; this involved removing or blasting large rough elements from the channel and constructing splash dams. These activities have promoted increased hydraulic efficiency and reduced LWD retention decades following disturbance.

Over the term of our HCP/NCCP, MRC assumes that our efforts to recruit instream LWD by leaving trees and artificially placing LWD will achieve the higher rates of LWD recruitment seen in old-growth stands.

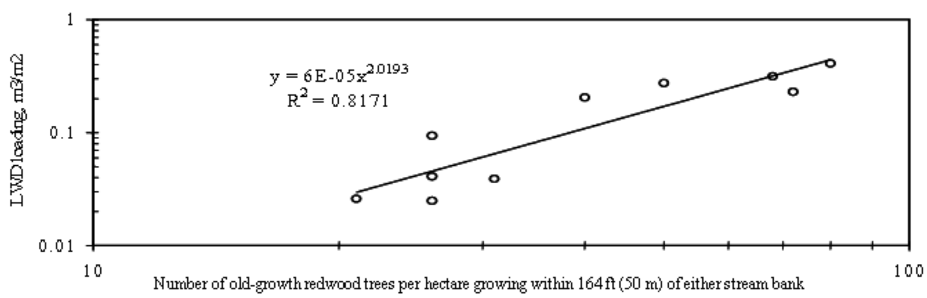


Figure 8-9 Relation between Redwood Tree Density and Instream LWD

LWD loading from a given recruitment zone was calculated by multiplying LWD loading values derived from the stand density relation (Keller et al. 1995) by the maximum and minimum cumulative percent LWD recruitment for the specified recruitment width (Reid and Hilton 1998). The resulting product adjusts LWD loading to recruitment within the specified width.

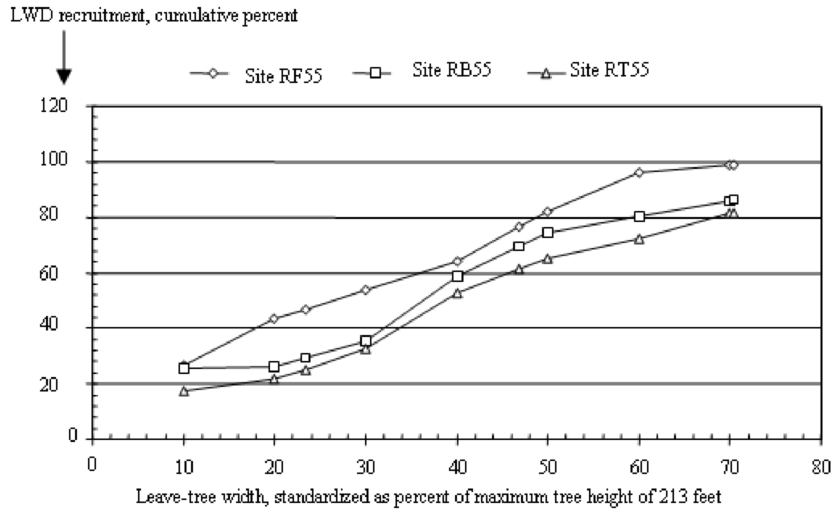


Figure 8-10 Source-distance Curves for LWD Delivery to Caspar Creek

DEFINITION	**Leave trees** are trees intentionally left standing after a harvest or thinning; the decision is a result of a predetermined management strategy.

Figure 8-11 describes the number of leave trees (per 100 m of channel length) required to reach LWD loading values for a given recruitment width. The value was calculated by multiplying the area of the recruitment zone on one side of the channel by the stand density (see Figure 8-9) associated with the LWD loading values. Because the recruitment zone is measured outward from the bank on one side of the channel, the resulting number of leave trees derived by this process pertains to one side of the channel. To meet long-term instream LWD loading objectives, an equivalent number of trees must be retained on the opposite side of the channel.

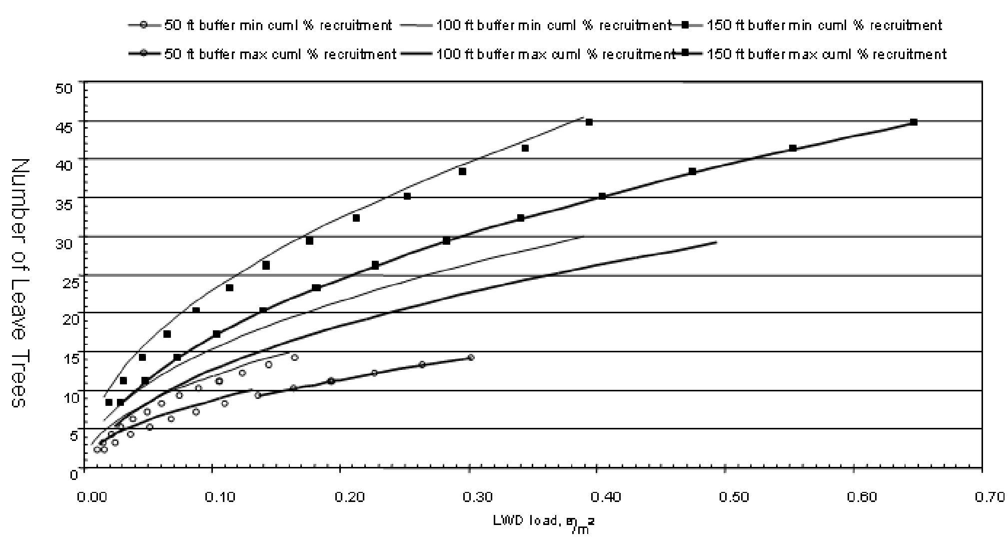


Figure 8-11 Leave Trees in Various Widths per 100 m of Channel

As of 2010, the estimated acres of AMZ in the plan area is 25,817; the proportion of AMZ acres within each site class is 4.3% in Site Class II (1108 ac), 93.1% in Site Class III (24,023 ac), and 2.7% in Site Class IV (686 ac). For our forestlands, MRC modeled tree numbers by size class within AMZ containing differing site classes; we projected forward for the 80-year term of our HCP/NCCP. Table 8-5, Table 8-6, and Table 8-7 show that, through the basal area retention for the AMZ, the number of large trees in the AMZ available for recruitment by varying site class categories will increase over the term of our HCP/NCCP.

Generally, across the plan area, Class I or Large Class II AMZs will meet the basal area trigger about 25-35 years after HCP/NCCP initiation; this will allow high retention selection harvests to occur. Using the modeled results at year 2035 for Site Class II and Site Class III, we concluded that retaining the largest 30% of trees greater than 12 in. dbh would yield 19 trees per acre. This estimate applies to a post-harvest situation.

MRC projects that a combination of riparian conservation measures for basal area and large tree retention will increase the number of large trees significantly over time. By 2035 there should be, on average, 17 trees greater than 24 in. dbh in Site Class II and Site Class III acreage; by 2075, their number should increase to 30. Using a range of 12-32 large trees retained per acre, MRC estimates 14-31 trees greater than 24 in. dbh per 100 m in Class I and Large Class II AMZ. We also estimate that the large tree retention for a 150-ft AMZ may result in LWD loadings ranging from 0.05-0.35 m^3/m^2, which is within the range of LWD loading observed in Prairie Creek, i.e., 0.05-0.31 m^3/m^2 (Keller et al. 1995). Some observations in Prairie Creek exceeded 0.31 m^3/m^2. These occurred exclusively in small channels that drain watersheds less than 1.5 km^2, considerably smaller than planning watersheds in the plan area.

Our analysis combines relations developed from old growth and managed redwood forest stands. Differences in recruitment processes and rates between old-growth and second-growth forests may significantly change the relation between standing tree density and LWD loading. In addition, our analysis focused on defining the number of leave trees necessary to establish a long-term supply of LWD from the buffer zone. MRC implicitly assumes in our analysis that standing tree density and LWD recruitment rate will remain constant despite changing stand characteristics and potential episodic loss of streamside trees from large floods, blowdown, and bank erosion.

Short-term recruitment may differ significantly from estimated long-term recruitment. The results of our analysis are best applied to settings where basin hydrology, valley geometry, and stand characteristics are similar to those in which the relations were developed. MRC will evaluate these parameters, as well as historical debris loading, at a given site before applying the method.

Given all these reservations, MRC still believes this model shows that LWD recruitment in the AMZ provided by our HCP/NCCP conservation measures can come close to providing the natural LWD recruitment levels demonstrated in Prairie Creek.

8.2.4.10 Fluvial transport of LWD

LWD that recruits to streams from adjacent riparian areas or from mass wasting can be relocated downstream through fluvial transport. This fluvial transport of LWD can impact LWD target ratings negatively or positively depending upon the sampling location.

Several characteristics of LWD influence its transport in streams, including size, density of pieces, and presence or absence of rootwads. Overall, smaller logs travel farther than larger pieces (Young 1994, Lienkaemper and Swanson 1987, both as cited in Braudrick and Grant 2000). The frequency of log movement increases with increasing stream size (Bilby 1985, Bilby and Ward 1989, Bilby and Ward 1991). Diameter strongly influences the depth of flow required to entrain and transport logs (Bilby and Ward 1989, Abbe et al. 1993). The presence of rootwads tends to influence transportation by affecting orientation, type of movement, and entrainment. Rootwads tend to anchor LWD (Abbe and Montgomery 1996). Unequal forces exerted on different parts of the log, including effects of rotation, must be considered when predicting entrainment (Braudrick and Grant 2000). Buoyancy is generally not a characteristic influencing LWD transport, as most debris is floating and only a few species contribute dense wood transported as bedload (Jacobson et al. 1999).

Several characteristics of streams influence LWD transport, including stream dimension, flow, sediment, and gradient. Low-order streams are susceptible to debris flows because they are adjacent to steep, landslide-prone slopes and because channels are narrow and high gradient (Swanson et al. 1982, Benda and Dunne 1997, Naiman et al. 1992 as cited in May 2002). In addition, in small streams large debris may influence channel morphology and sediment transport processes as streams may not have the capability to redistribute debris (Keller and Swanson 1979). Stream flow, which is partly a function of watershed and stream size, influences the size of LWD that can be transported as well as the frequency of debris jams. Debris jams tend to occur more frequently in streams with low stream discharge rates. In addition to stream flow, bed roughness may be a factor influencing movements, with coarse sediment being more likely to increase resistance (Braudrick and Grant 2000).

In first order streams, nearly 75% of the standing stock of organic matter is contained in organic debris dams. The proportion decreases to 58% in second-order streams and to 20% in third-order streams (Bilby and Likens 1980). Frequency of dams is higher in smaller streams. Lower discharge makes it possible for smaller pieces to form the framework of a debris dam and also makes it less likely that a large piece of debris will be dislodged and carried downstream. Legacy wood (often unrelated in species or in size to the present day forest) can be stored for long periods in small streams even if the area has recently undergone extensive harvesting (May 2002). The highest reported quantities of woody debris (660 Mg/ha) are found in streams draining basins of less than 2471 ac (1000 ha) and flowing through old-growth coastal redwood stands in north coastal California (Keller et al. 1986, as cited in Lienkaemper and Swanson 1986). Streams of similar size flowing through other types of old-growth coniferous forests in northwestern North America contain 100 to 300 Mg/ha (Harmon et al. 1986, as cited in Lienkaemper and Swanson 1986).

Logs tend to be stable when more than half their length is outside the channel because less of the piece is exposed to flow (Lienkaemper and Swanson 1987). Piece length appears to be the most important factor influencing the stability of a log that is oriented parallel to flow (Abbe and Montgomery 1996, Nakamura and Swanson 1994, both as cited in Braudrick and Grant 2000). Most mobile pieces are shorter than bankfull width (Nakamura and Swanson 1994). Braudrick and Grant (2000) showed that the two most important factors influencing LWD entrainment are orientation of the piece and the presence or absence of rootwads. Diameter strongly influences depth of entrainment depending on substrate size (Braudrick and Grant 2000).

The likelihood of a log jam is higher in low-order streams. Congestion of pieces increases with increase in particle interaction (Braudrick et al. 1997). The ratio of log diameter to water depth (D_{log}/d_w) and the ratio of log length to channel width (L_{Log}/w_c) appear to be important factors in initiating log jams (Abee et al. 1993, Nakamura and Swanson 1994, both as cited in Braudrick et al. 1997). In studies conducted by Braudrick et al. 2000, the type of transport regime—congested, un-congested, or semi-congested—depended mainly on the ratio of log volume delivered to the channel per second (Q_{log}) to discharge (Q_w), varying between 0.015 for un-congested and 0.20 for congested areas

During monitoring and especially through focus watershed studies, MRC collects most of the data relevant to LWD transport on our land, including size, presence of rootwads, and location on or beneath earth's surface. Based on our understanding of this data, we have proposed conservation measures for placement of LWD in Class I watercourses (C§8.2.3.6-1 through C§8.2.3.6-20).

8.2.4.11 Shade retention and stream water temperature

Removal of tree canopy following logging can increase the amount of solar radiation reaching a stream (i.e., loss of stream shade), causing increased maximum temperatures and greater diurnal fluctuations (Beschta et al. 1995). Temperature increases are typically greatest during summer (MacDonald et al. 1991), when stream temperatures are naturally at their peak due to maximum incident radiation. Because the influence of solar radiation diminishes with increasing stream depth and discharge, these effects tend to be greatest in small streams (Beschta et al. 1995, Spence et al. 1996). Long-term effects of timber management on stream temperatures depend on a number of interrelated factors, including spatial distribution of harvesting, amount of overstory canopy removed, and management of riparian vegetation following harvesting (Beschta et al. 1995, Spence et al. 1996). Orientation of a stream (e.g., north-south vs. east-west), steepness of adjacent hillslopes, and amount of groundwater and subsurface flow can also affect the magnitude of temperature increase following riparian canopy removal (Cafferata 1990, Beschta et al. 1995, Murphy 1995).

Canopy cover is important in reducing the net gain of solar radiation. Stream water temperature responds to the input of solar radiation and is directly proportional to exposed stream surface area (Brown and Krygier 1970) and inversely proportional to discharge (Sullivan et. al. 1990). Wide stream exposures receive greater solar radiation then streams with good canopy cover and narrow solar exposure. Several studies have shown that an intact streamside forest canopy will shade streams and minimize increases in summer water temperature. Brown and Krygier (1970) found diurnal variations in a well-shaded coastal Oregon stream to be less than 1^0 C. However, complete removal of the forest canopy has been shown to increase summer maximum temperatures $3\text{-}8^0$ C (see Beschta et. al. 1987). In a comparison of 20 years of temperature records from Steamboat Creek, Oregon, Hostetler (1991) found that streamside canopy cover was the most important variable linked to changes in stream temperature.

MRC expects our AMZ retention standards for canopy and large trees to ensure adequate streamside shading and maintain cool stream temperatures. Increased canopy closure—85% in the inner band of the AMZ—will ensure solar deflection and direct shading from trees over watercourses. The inner and middle bands of Class I and Large Class II AMZ will retain the largest percentage of trees. Retaining these largest trees along the watercourse will ensure that they are able to grow to tall heights. In the appropriate hillslope aspect (i.e., the south banks of streams), tall trees will help deflect solar radiation that cannot be deflected by direct canopy over or adjacent to the watercourse. Upslope, our long-term strategy is to use uneven-aged management to effectively extend the angular canopy of the riparian zone and provide an extra measure of protection for streams. Table 8-8 **s**hows the average tree height and number of trees per acre greater than 24-32 in. dbh and greater than 32 in. dbh projected for Class I and Large Class II watercourses across the plan area.

After approximately 25-30 years, the average height of trees greater than 24 in. dbh approximates the lower end of the range for a redwood tree height (133 ft) in Site Class III. After approximately 65 years, the average height of trees greater than 24 in. dbh approximates the upper end of the range of a redwood tree height (150 ft) in Site Class III. Furthermore, the number of trees of this size increases. MRC anticipates that this increase in average tree height and number of larger trees in Class I and Large Class II AMZ will improve the stream shade potential of AMZs.

MRC will experiment, through adaptive management and AMZ restoration harvests, with different levels of canopy retention based on various factors: (a) aspects of the stream and adjacent riparian stands; (b) proximity of the stands to the coast with its fog and cool temperatures; and (c) size of the watershed. Our purpose is to improve shade retention guidelines and stream temperature management. Sullivan et al. (1990) developed a concept of threshold distance, i.e., distance from the watershed divide where stream temperature was no longer a function of streamside canopy but a function of air temperature. They suggested this threshold distance from the watershed divide is 40-50 km in Washington State. Stream temperature analysis from coastal northern California (Lewis et. al. 2000) suggests the threshold distance may be 70 km from the watershed divide.

8.2.4.12 Riparian microclimate maintenance

The riparian zone functions as a significant regulator of microclimate, affecting both terrestrial and aquatic environments. The most substantial microclimate controls provided by the riparian corridor include

- Regulation of humidity.
- Interruption of wind velocity.
- Modification of both soil and air temperature.

These functions may have cumulative effects on species within the AMZ and can be routed from headwaters to downstream reaches.

Riparian vegetation effectively works to increase relative humidity by filtering solar radiation and reducing wind velocity (FEMAT 1993, Brosofske et al. 1997). Relative humidity and wind velocity can have modest effects on water quality and, therefore, are not conveyed downstream. They do directly affect covered species residing within Class I and Class II streams and the AMZ. Changes in these functions within the riparian zone can influence the migration and dispersal of flying insects that may be a significant portion of the anadromous salmonid and amphibian prey base (Brosofske et al. 1997, Chen et al. 1995). In addition to food implications, amphibians rely on high levels of relative humidity and reduced levels of wind velocity to prevent dehydration and to ensure that proper respiratory functions can be carried out (FEMAT 1993, Brosofske et al. 1997).

By reducing solar radiation, riparian vegetation also moderates air temperature. Air temperature, like humidity and wind velocity, influences the migration, dispersal, and productivity of flying insects that are food for salmonids and amphibians (Chen et al. 1995). Similarly, amphibians require cool temperatures for respiratory functions and dehydration prevention (FEMAT 1993, Brosofske et al. 1997). In addition, air temperature has a direct influence on water temperature and evapotranspiration rates (Ledwith 1996). Water temperatures and levels affect survival and growth rates of covered species within Class I and Class II streams; changes in these water quality conditions can be routed downstream.

Soil temperature, which is lowered through the action of riparian vegetation, is another microclimate condition that impacts stream systems at the site and downstream. Water temperature is influenced by soil temperature within riparian areas and even upslope regions (Brosofske et al. 1997, Welsh et al. 2005).

Opening canopies in riparian zones may result in modification of climate and landscape processes at the scale of the drainage basin (Chen et al. 1999). Uneven-aged management, as MRC practices, prevents clearcuts adjacent to streams, except for rehabilitation of hardwood-dominated stands or conifer stands with poor growth. MRC will limit these restoration treatments and their effects on stream water temperature through adaptive management.

MRC anticipates that our forest management upslope from streams will influence microclimate. However, various AMZ protections should make this influence minimal, particularly the use of an outer band on the AMZ to buffer the inner and middle bands. Moreover, our harvest methods of selective and variable retention will result in varying tree retentions providing some buffers to riparian micro-climate.

8.2.4.13 AMZ restoration treatments

AMZ restoration treatments will improve riparian function by promoting development of late seral conifer stands. Through active management, this will provide, in the long term, improved LWD recruitment and shade for watercourses. AMZ treatments will take into account water temperatures necessary for coho salmon, steelhead, and coastal tailed frogs, as well as slope stability to minimize mass wasting.

To meet riparian function, one biological objective of our HCP/NCCP is to improve tree species composition and move toward pre-management levels. This requires conversion of hardwood-dominated stands, created from past silvicultural practices, to stands dominated by redwood and Douglas fir. Table 3-19 shows the distribution of acres in the plan area with a significant hardwood component.

As of 2011, 42% of the plan area has a significant hardwood component; this includes the AMZ. Certainly disturbances from fire or mass wasting made this hardwood component fluctuate over time. The climax species, however, for the majority of the plan area is conifer. Conifers grow taller and larger than hardwoods and provide larger, longer-lasting LWD for instream habitat. In addition, they produce multi-storied canopy to shade streams and intercept rainfall. Restoration harvests will accelerate small conifer stands with poor growth toward late seral conifer stands which promote riparian function. Moreover, conifers are commercially more viable than hardwood species.

MRC wants to better understand how to reduce the risk of increased water temperatures. Such increases could adversely impact, in the short term, aquatic species covered in our HCP/NCCP. The majority of AMZ restoration treatments will be in the middle and outer bands of the AMZ of Class I and Class II watercourses. Maintenance of stream temperature will limit the amount of treatment in the inner band. Vegetation closest to the stream, in the inner band of an AMZ, has the greatest influence on stream shading. Therefore, MRC will retain at least 70% canopy in the inner band and will not conduct restoration treatments there if stream temperature exceeds the MWMT upper threshold (Table 8-12). This is specifically to protect cold water species covered in our HCP/NCCP—coho salmon, steelhead, and coastal tailed frogs.

The MWMT upper threshold of 18°C for coho salmon was derived from Welsh et al. (2001), who observed in the Mattole River watershed that coho salmon were not likely to be present in a stream if the MWMT exceeded this level. Our own data on fish distribution and stream temperature indicates that the majority of streams in the plan area with coho salmon have MWMT levels between 16-18°C; this defines the middle threshold. MWMT levels below 16 °C do not present stressful conditions for coho salmon; therefore, this defines the lowest temperature threshold.

Examination in the plan area of fish distribution and stream temperature data for steelhead does not indicate any apparent MWMT threshold. There are streams and rivers where the MWMT is as high as 26°C and juvenile steelhead are present. This suggests that steelhead can exist in higher stream temperatures than coho salmon. In the absence of a published threshold for steelhead, MRC will use a conservative MWMT of 21° C for the upper temperature threshold; this is 3 °C higher than the threshold for coho salmon. Steelhead are commonly found in streams in the plan area with temperatures between 17-21° C; this defines the middle threshold for steelhead. MWMT levels below 17 °C do not present stressful conditions for steelhead; this defines the lowest temperature threshold.

MRC chose a 15% restriction, based on water temperature and species present, for restorative treatments along a linear distance of watercourse within a planning watershed. This appears to be a reasonable level to limit streamside disturbances yet also provides MRC with the opportunity to meet our restoration objectives for riparian stands. The percent of stream length with restoration treatments is limited by a 10-year time frame to ensure sufficient re-growth prior to further restoration treatments. MRC will phase in the restoration treatments slowly in conjunction with monitoring to ensure that the restoration treatments proposed do not create adverse conditions.

The AMZ provides protections that may also lower risk of sediment delivery from mass wasting sediment. The conservation measures that apply for mass wasting hazard still apply when AMZ restoration treatments are used. The exception to this is on steep streamside slopes (not inner gorge slopes) in TSU1 and TSU2. On steep streamside slopes, AMZ restoration treatment must maintain 50% overstory canopy for slope stability. MRC will avoid extreme mass-wasting hazards, such as inner gorge topography or active landslides, in our restoration treatments.

8.2.4.14 Class III AMZ silvicultural treatments

The high amount of hardwood-dominated acres within Class III AMZ will require unique silvicultural treatments, such as restoration harvests. Table 8-14 shows the estimated amount of harvest required to treat significant hardwood components during the first 25 years of our HCP/NCCP. To limit the impacts of Class III restoration treatments, MRC will only treat 15% of a watercourse length within each decade.

Table 8-14 Estimated Amount of Acres in Class III AMZs within the Plan Area

Inventory Block	Estimated Acres of Class III AMZ [2]	Estimated Hardwood Acres in Class III AMZ [1,2]
Albion	1258	142
Big River	2813	1404
Garcia River	1249	538
Navarro East	2534	956
Navarro West	1977	852
Noyo	1628	470
Rockport	3224	1759
South Coast	2865	1147
Ukiah	301	173
TOTAL	17,850	7440

TABLE NOTES
[1]Data includes vegetation strata containing mixed conifer/hardwood and mixed hardwood.
[2]Measurements of Class III watercourses are from sample THP maps. Results of these calculations showed that for the plan area an average of 4.2% of harvest unit acres were in Class III AMZ with a range of 0-13%. Calculations assumed a 50-ft buffer on each side of all Class III watercourses.

8.2.4.15 Streambank stability

Sediment delivery to streams can originate from different sources and be influenced by different factors. In steep, dissected, and soil-mantled hillslopes of the humid and forested Pacific Northwest region, mass wasting processes (i.e., landslides, creep, and biogenic transport) are naturally a dominant source of erosion on hillslopes and a source of sediment delivery to stream channels (Swanson et al. 1982, Dietrich et al. 1986, Dietrich et al. 1998, Roering et al. 1999). Stream bank failures are a product of undercutting and tend to be more numerous in lower parts of basins (Kelsey et al. 1995). Stream bank failure is a naturally occurring process. Its primary cause is erosion from stream processes, such as meandering, where flow impingement concentrates hydraulic force to the outer banks of meander bends causing retreat across and down the valley. Eroded bank material is transported downstream to the next point bar, where outer bank erosion is balanced by bar deposition and advance. Other causes can include heavy rainfall and debris jams. The extent to which such erosion occurs, however, depends on topography, soil composition, bank vegetation, precipitation patterns, as well as human impacts. In some areas with stable slopes, natural erosion of stream banks contributes only a small amount of overall sediment input into the stream channels. In other watersheds, however, it can be a larger percentage of the total input.

Table 8-15 Sediment Delivery to Stream Channels from Stream Bank Erosion (1942-1997)

Sediment Delivery to Stream Channels from Stream Bank Erosion				
Selected Watersheds in the Redwood Region				
Watershed	% Natural Stream Bank Erosion[b]	% Management Related Erosion[c]	Years Analyzed	Source
Freshwater Creek	9	<1	1942-1997	PALCO 2001
Upper Freshwater	20	1		
South Fork	8	1		
Graham Gulch	5	1		
Cloney Gulch	7	0		
Little Freshwater	1	0		
McCready Gulch	2	0		
Lower Freshwater	4	0		

Sediment Delivery to Stream Channels from Stream Bank Erosion				
Selected Watersheds in the Redwood Region				
Watershed	**% Natural Stream Bank Erosion[b]**	**% Management Related Erosion[c]**	**Years Analyzed**	**Source**
School Forest	0	0		
Grouse Creek	0		1976-1989	Raines 1998
Navarro River[a]	3		1975-1998	USEPA 2000
Redwood Creek	12		1954-1997	USEPA 1998b, Redwood National and State Parks 1997

TABLE NOTES
[a] The plan area is partly in this watershed
[b] Natural processes, such as stream meandering or heavy rainfall, induce stream bank erosion.
[c] Management for fish habitat induces stream bank erosion; bank erosion is influenced by the presence of railroad ties and corduroy roads in the streambed, erosion of sediments deposited in the stream during previous harvest activities (skid trails in the channel), and erosion-related adjustment of headwater channels following the first-cycle harvest.

Bank erosion in second growth redwood was estimated in the Van Duzen watershed (Humboldt and Trinity Counties). Relatively high rates of bank erosion (average 0.11 m/yr) were found when compared to old growth redwood stands in Prairie Creek (average 0.014 m/yr). This difference appeared to be the result of large floods and of channel meandering and migration against erosion-prone banks. In both old and second growth sites, wood recruitment from sources other than landsliding generally originated 65-131 ft (20–40 m) from the stream; wood recruitment from bank erosion was approximately within 16 ft (5 m) of the stream (Benda et al. 2002). In Prairie Creek, bank erosion was responsible for more than 50% of wood volume. The proximity of tree-fall to the channel suggests, however, that mortality is higher closer to the stream. This is due perhaps to wetter soils and susceptibility to windthrow from opened canopy near the channel rather than bank cutting.

Table 8-15 shows that bank erosion is fairly small in watersheds in the Coast Range of northern California. MRC will address bank stability through (a) retention of streamside vegetation, (b) increased vegetation retention within flood-prone and channel migration areas, and (c) exclusion of equipment adjacent to Class I and Class II watercourses.

Data from MRC timber inventory indicates that coast redwood and Douglas-fir trees with 36 in. dbh have crown diameters, on average, of about 25 and 36 ft, respectively. The root strength of conifers declines sharply at distances beyond the radius of the tree crown (FEMAT 1993). With diameters of 25 and 36 ft, the radius of the crown minus the radius of the tree stem is approximately 11 and 16.5 ft respectively (using a 36 in. diameter stem). The 10-ft distance for *no harvest* of single stemmed trees encompasses the majority of a crown radius of a mature tree and provides a consistent measurement for easy implementation. To ensure root structure is present, particularly for undercut banks, MRC will retain all trees that have their roots exposed in the bank. If a rootwad is a redwood clump, we will retain 50% of the stems following a harvest. In addition, we will measure the 10-ft bank stability zone from the start of the undercut bank.

8.2.4.16 Surface erosion in the AMZ

Erosion and the deposition of sediment are natural events. Erosion results from wind, water, gravity, and other processes. A certain amount of erosion can be vital to both terrestrial and aquatic ecosystems. Gravels, for example, continuously move downstream and create spawning beds for fish. When natural erosion is intensified by human land use, it can result in loss of soil or sediment build-up in streams that threatens fish survival.

Riparian areas provide function as "filters" for un-channeled fine sediment originating on roads, skid trails, and tractor landings. Their effectiveness in this capacity depends on (a) sediment size; (b) hillslope gradient; (c) infiltration rate; (d) structural characteristics of the vegetation and litter layer; and (e) runoff characteristics (Johnson and Ryba 1992). Studies reviewed by Johnson and Ryba (1992) suggest that the relationship between the width of a riparian buffer and the efficiency of its vegetation to remove sediment is non-linear. For example, studies indicate that the width of riparian buffer would need to be doubled in order to increase the efficiency of sediment removal from 90 to 95%. On slopes less than 50%, Broderson (1973, as cited in Spence et al. 1996), found that a buffer width of 50 ft (15 m) controlled most sediment.

Much of the sediment (both fine and coarse) that reaches stream channels, however, is transported by channel flow. Runoff from roads and inboard ditches along roads often reach at least an intermittent tributary without passing through a riparian area. Debris torrents and debris slides generally have enough energy to travel through any riparian area in their path. At least on steeper slopes, gullies from concentrated road drainage have the same ability. In specific situations, riparian buffers may trap fine sediment before it reaches a watercourse, but riparian protection should not form the basis of a program to reduce sediment input to stream channels (Spence et al. 1996). The emphasis on greater vegetation retention and fewer disturbances closer to a watercourse in the AMZ (inner band) will limit exposed soils that can deliver to watercourses by surface erosion. This will reduce the flow paths and delivery of sediment from roads and mass wasting.

8.2.4.17 Nutrient cycling

The function of the riparian zone on nutrient supply, storage, and cycling is vital to an aquatic ecosystem. Nutrients and particulate organic matter can move in both downstream and lateral directions, and thus have several important effects on covered species and their food base.

Riparian vegetation is the primary supplier of nutrients for most streams; it provides allochthonous inputs to all reaches. Direct litterfall, in addition to lateral movement of organic debris within the riparian zone, provides an energy base for streams and supplies nutrients for aquatic organisms that are transferred through food webs (Gregory et al. 1991). For example, invertebrate production relies heavily on allochthonous production, which is initiated in headwater reaches. This production then benefits salmonids and amphibians that reside in lower reaches by enhancing their prey base. As this material moves downstream, species abundance and composition will be affected according to levels of this input and degree of processing (Vannote et al. 1980). Constant breakdown of LWD provides a buffer for the energy base of the biota during periods when few leaves or needles are available (Swanson et al. 1982).

Cycling of nutrients within a riparian corridor is largely a function of its vegetation. Riparian vegetation not only supplies nutrients in the form of organic debris, but also regulates the amount of dissolved nutrients entering a stream through active uptake (Gregory et al. 1991). Riparian vegetation can leach nutrients stored in soils and allow excess nutrients to enter a stream during runoff events. The abundance and composition of this vegetation will determine the amount of nutrients extracted and routed downstream.

Finally, riparian vegetation provides for storage of materials. Surface roughness created by riparian vegetation within a floodplain captures and stores nutrient-rich particulate organic matter (Swanson et al. 1982). This trapped material is then exchanged at the land-water interface during periods of overbank flow. Materials are able to move both laterally and downstream during these periods (Gregory et al. 1991), and will consequently affect salmonids and amphibians.

The AMZ protections that MRC proposes provide for vegetation and protection of floodplains on all classes of watercourse, including those watercourses with no aquatic organisms present (Class III). These protections, we believe, should minimize the impacts that forest management has on nutrient cycling in the riparian zone.

Table 8-16 summarizes the rationale for proposing different levels of watercourse protection and the contribution of vegetation to riparian function.

8.3 Sediment inputs

8.3.1 Overview

8.3.1.1 Mass Wasting

It is neither necessary nor beneficial to eliminate all erosion. Some erosion is a natural part of a healthy ecosystem. Forest management, however, can increase incidence of mass wasting and delivery of sediment to streams. This, in turn, can damage aquatic habitat and threaten species dependent on that habitat. MRC proposes to minimize mass wasting and sediment delivery in the plan area. In this section, we address timber activities that can result in significant mass wasting:

- Road and landing construction.
- Use of existing haul roads and landings.
- Tractor yarding.
- Tractor trail construction and reconstruction.
- Timber harvest and site preparation.

MRC will minimize sediment delivery during covered activities. Activities will include PTHPs, road construction, and other forest management. MRC will analyze mass wasting and propose protection measures based on watershed analysis units. For example, we will control reductions in canopy to ensure that sub-surface water levels in a watershed are not significantly altered. This will reduce the likelihood of increased mass wasting from altered hydrologic processes.

MRC strategy emphasizes high protection near watercourses where the risk for sediment delivery from mass wasting is critical. This is especially true for inner gorge terrain and steep streamside slopes. MRC will promote the upslope integrity of hydrologic processes and tree-root strength through default conservation measures for specific terrain. Furthermore, MRC will retain larger trees to provide LWD to stream channels if a hill-slope failure does occur. Within each CalWater planning watershed across our timberlands, MRC will also retain at least 50% average overstory canopy to mitigate the effects of timber harvest on hydrologic changes at the watershed scale.

Table 8-16 Riparian Functions by Watercourse Type

Riparian Functions by Watercourse Type					
Riparian Function	Processes Common to All Channels	Processes Directly Affected			
		Class I	Large Class II	Small Class II	Class III
Definition					
		Fish bearing	Non-fish bearing but supports aquatic life (basin area >100 ac)	Non-fish bearing but supports aquatic life (basin area <100 ac) No year round flow	Supports no aquatic life or able to deliver sediment via surface flow to a Class I or Class II watercourse
Use by Covered Species					
		All life stages of Chinook salmon, coho salmon, steelhead, and coastal tailed frog	All life stages of amphibians	Winter use by amphibians, and summer use by red-legged frogs for hydration during migration	
Woody Debris Recruitment					
Contributes LWD	Riparian zone provides long-term input of LWD, which is recruited to a channel from windthrow, bank cutting and mass wasting.	Frequent formation of LWD accumulations	Routes LWD to Class I watercourses during high flow and mass wasting events	Routes LWD and SWD to Class I watercourses during mass-wasting events	Routes LWD to Class I and II watercourses during mass wasting events
	LWD stores coarse and fine sediment, provides grade control and channel stability, and collects smaller woody debris (SWD).	LWD creates channel and habitat complexity for salmonids and amphibians through pool formation and sediment sorting.	LWD and SWD can be stable with periodic to frequent accumulations.	LWD provides habitat complexity for amphibians.	Residency time is relatively long, which reduces gullies.
	Size of wood required for stability in channels increases with channel size. Variable residency time depends on channel size, and thus the ability of LWD to function depends on size of woody debris and channel width. (Bilby and Ward 1989).	LWD sorts and supplies small organic material used by invertebrates as a food resource.	LWD provides habitat complexity for amphibians.	Residency time is relatively long; small and large pieces are stable.	Small and large pieces are stable.
	Constant breakdown of LWD provides "a buffer for the energy base of the biota during periods when few leaves or needles are available" (Swanson et al. 1982).	LWD traps anadromous salmonid carcasses that supply nutrients to the ecosystem.	LWD sorts and supplies small organic material used by invertebrates as a food resource.		Provides grade control for channel stability.

Riparian Functions by Watercourse Type					
Riparian Function	**Processes Common to All Channels**	**Processes Directly Affected**			
		Class I	**Large Class II**	**Small Class II**	**Class III**
Shade Retention and Water Temperature					
Provides shade	Riparian vegetation reduces solar input to streams to moderate stream temperature. Stream shading is also influenced by valley aspect. Shade provided by riparian vegetation influences autochthonous production by regulating available light (Vannote et al. 1980).	Overstory canopy provides the majority of shade on large channels to moderate summer water temperatures. Salmonids and amphibians require cool stream temperatures.	Overstory canopy and understory vegetation provide shade to moderate summer water temperature. Cool stream temperatures are necessary for amphibians. Stream temperatures can influence Class I stream temperatures downstream.	There is no flow in Small Class II streams during summer when temperature is a concern. As a result, Small Class II streams do not influence temperatures in Class I or Large Class II streams during summer.	There is no connection between Class III streams and Class I or II watercourses when temperature is a concern (summer).
Nutrients					
Supplies nutrients	Direct litterfall and lateral movement in the form of organic debris provides an energy base for streams, supplying nutrients for aquatic organisms that are transferred through food webs (Gregory et al. 1991).	Invertebrate production provides prey for salmonids and amphibians, and relies heavily on allochthonous inputs; however, this shifts to autochthonous inputs as stream size increases.	Invertebrate production provides food for amphibians and relies heavily on allochthonous inputs. Excess nutrients are transported downstream to Class I streams.	Invertebrate production relies heavily on allochthonous inputs, and invertebrate production affects amphibians. Excess nutrients are transported downstream during periods of flow.	Organic matter is stored and transported downstream during periods of flow.
Functions in nutrient cycling	Riparian vegetation uptake regulates amount of nutrients entering channels that will consequently be routed downstream (Gregory et al. 1991).	Nutrient production affects the prey base salmonids and amphibians, and is transported downstream.	Nutrient production effects the food base for amphibians, and nutrients are transported downstream to Class I streams.	Nutrient production affects the food base for amphibians, and nutrients are transported downstream during periods of flow.	Nutrients are transported downstream during periods of flow.
Traps nutrient-rich particulate organic matter	Surface roughness created by riparian vegetation within the floodplain captures and stores nutrient rich particulate organic matter (Swanson et al. 1982). This material is consequently exchanged at the land-stream interface during over bank flows. Entrained material can move laterally and downstream (Gregory et al. 1991).	Exchange of nutrients and particulate organic matter within the floodplain occurs during overbank flow, and this transfer affects salmonids and amphibians.	Exchange of nutrients and particulate organic matter within the floodplain occurs during overbank flow, and this transfer can affect amphibians.	Exchange of nutrients and particulate organic matter within the floodplain occurs during overbank flow, and this transfer can affect amphibians.	Floodplain processes are not a factor for Class III streams.

Riparian Functions by Watercourse Type					
Riparian Function	**Processes Common to All Channels**	**Processes Directly Affected**			
		Class I	**Large Class II**	**Small Class II**	**Class III**
Microclimate					
Regulates relative humidity	Riparian vegetation increases relative humidity by reducing solar radiation and wind within riparian environments.	Can influence migration and dispersal of flying insects that are prey for salmonids and amphibians (Brosofske et al. 1997, Chen et al. 1995).	Amphibians rely on high levels of humidity to prevent dehydration and allow respiratory functions (Brosofske et al. 1997, FEMAT 1993).	Amphibians rely on high levels of humidity to prevent dehydration and allow respiratory functions during periods of inhabitation (Brosofske et al. 1997, FEMAT 1993).	
Interrupts wind velocity	Riparian vegetation controls wind velocity and degree of wind penetration into riparian environments.	Can influence migration and dispersal of flying insects that are prey for salmonids and amphibians (Brosofske et al. 1997, Chen et al. 1995)	Amphibians rely on low wind velocity to prevent dehydration and allow respiratory functions (Brosofske et al. 1997).	Amphibians rely on low wind velocity to prevent dehydration and allow respiratory functions during periods of inhabitation (Brosofske et al. 1997).	
Moderates air temperature	Riparian vegetation lowers air temperature by reducing solar radiation within riparian environments. Air temperature directly affects water temperature and evapotranspiration rates (Ledwith 1996).	Can influence migration, dispersal, and productivity of flying insects that are prey for salmonids and amphibians (Brosofske et al. 1997, Chen et al. 1995). Salmonids and amphibians have specific thermal ranges for survival and reproduction.	Amphibians rely on cool temperatures to prevent dehydration and allow respiratory functions (Brosofske et al. 1997, FEMAT 1993).	Amphibians rely on cool temperatures to prevent dehydration and allow respiratory functions during periods of inhabitation (Brosofske et al. 1997, FEMAT 1993). Increased air temperatures can lower groundwater levels and soil moisture content, and may dry up intermittent streams. The lack of water in these reaches may deprive amphibians of an essential source of water during dry periods (Ledwith 1996).	
Moderates soil temperature	Riparian vegetation lowers soil temperature by filtering solar radiation within riparian environments.	Water temperature is influenced by soil temperature (Brosofske et al. 1997), and this can affect salmonids and amphibians.	Water temperature is influenced by soil temperature (Brosofske et al. 1997) and can affect amphibians and limit their dispersal (Chen et al. 1999).	Water temperature is influenced by soil temperature (Brosofske et al. 1997) and can affect amphibians and limit their dispersal (Chen et al. 1999).	

Riparian Functions by Watercourse Type					
Riparian Function	Processes Common to All Channels	Processes Directly Affected			
		Class I	Large Class II	Small Class II	Class III
Streambank Stability					
Enhances streambank stability	Intact roots as well as embedded and fallen logs within the riparian zone decrease erosion of banks, reduce water velocity, and promote the formation of undercut banks (FEMAT 1993, Sedell and Bescheta 1991, Swanson et al. 1982).	Salmonids depend on bank habitat for predator avoidance and refuge from high flows. Streambank failure and erosion can become chronic sediment sources.	Amphibians can use bank habitat as cover. Streambank failure and erosion can become chronic sediment sources.	Amphibians can use bank habitat as cover. Sediment delivery from bank failure is transported downstream during periods of flow.	Sediment from stream bank failure can be routed downstream, or delivered during mass wasting events.
Surface Erosion					
Prevents surface erosion	Riparian understory vegetation and associated downed debris, duff, and litter can filter sediment from overland flow off adjacent hillslopes (NMFS 2000c).	Salmonids are sensitive to fine sediment from surface erosion that can directly affect all life history stages (Spence 1996).	Amphibians are sensitive to fine sediment that can inhibit reproduction and foraging (FEMAT 1993).	Amphibians are sensitive to sedimentation that can inhibit reproduction and foraging (FEMAT 1993). Sediment inputs are routed downstream during periods of flow.	Sediment from overland flow is routed downstream.

Although MRC is focusing our current and long-term strategy on uneven-aged management, some regeneration of even-aged stands will occur. There are various methods used to regenerate a stand with one age class, including clearcut, shelterwood, and seed steps. During such regeneration, MRC will follow default conservation measures for specific terrain. There will be no even-aged regeneration harvests within inner gorges or other areas of high risk for sediment delivery from mass wasting, such as historically active landslides. A small percentage of hardwood-dominated terrain with a high hazard for mass wasting will require some regeneration of even-aged stands in the initial decades of our HCP/NCCP. Within any 10-year period, this percentage will not exceed 5% of any high hazard terrain unit within a CalWater planning watershed area. MRC will track the percentage of regenerated even-aged stands in each CalWater planning watershed using a 10-year rolling system. The 5% of terrain requiring even-aged management cannot exceed 5 ac in each high hazard terrain unit within a PTHP. Section 8.3.4.5 provides further explanation and justification for the 5% limit on regenerated even-aged stands in high hazard terrain. This alternative to the default conservation measures will likely occur within the first 30 years of our HCP/NCCP, when hardwood conversion and forest restoration are taking place.

Mass Wasting Site in the Plan Area

Watershed analysis has, as one of its components, an evaluation of the mass wasting and geomorphic setting and its sensitivity to sediment inputs. Mass wasting assessment in watershed analysis targets several objectives:

- Identification of the types of mass wasting processes in a watershed.
- Identification of possible links between mass wasting and forest management.
- Zoning of the plan area based on mass wasting potential.
- Estimation of the magnitude of sediment delivery from mass wasting processes.

DEFINITION

A **Terrain Stability Unit (TSU)** is a categorization of a land area based on terrain similarity, mass wasting potential, and sediment delivery risk.

For our HCP/NCCP, a California professional geologist supervised the identification of mass wasting processes and the zoning of the plan area into 8 TSUs. TSUs serve as a guide to foresters in determining areas of potential mass wasting hazard and suggesting appropriate management action to minimize risks to aquatic habitat.

For each TSU, MRC has default conservation measures. MRC may change default conservation measures through minor modifications to our HCP/NCCP (see section 1.13). Apart from these minor modifications, site, watershed, and plan changes require either adaptive management (see Chapter 13, *Monitoring and Adaptive Management*) or a major amendment to our HCP/NCCP (see section 1.13 and Appendix A, *Implementing Agreement*, section 9.0). Working with the wildlife agencies, MRC will ensure that any change to a default conservation measure does not increase the risk of sediment delivery from mass wasting.

In some cases, MRC will not complete watershed analyses by the time our HCP/NCCP takes effect. These instances will require additional field reviews by individuals trained in identification of mass wasting features, TSU categories, and risks of sediment delivery.

8.3.1.1.1 Implementation of mass wasting strategy at the project level

A project manager, in this case an RPF, will gather all available information on mass wasting issues in a project area. Information sources will include (a) MRC watershed analysis data, such as landslide and TSU maps; (b) landslide and geomorphic maps from the California Geological Survey; (c) designations of unstable areas from past PTHPs; and (d) other sources, if available. Such information will pinpoint potential features and hazards for mass wasting in a project area. MRC reports on anadromous salmonid and amphibian distribution will also help determine the level of risk to aquatic species from a proposed project.

With all this information at hand, MRC will conduct an initial field review. An individual trained by a professional geologist in identification of mass wasting hazards will make the initial determination. The field review will determine if, and where, historically active instability exists. It will also verify the precise location of TSU boundaries and evaluate downstream habitats. The reviewer will use a modified version of the California Licensed Foresters Association (CLFA) checklist for mass wasting (CLFA 1999). The modified *CLFA Checklist* is included in Appendix J (section J.1). The modification includes additional indicators of slope instability; this makes the checklist more comprehensive for identifying historically active landslides (i.e., those landslides that have experienced movement within the past 100 years). If required, an individual knowledgeable in the aquatic biological resources of the area may conduct a follow-up visit. This person will assess the relative sensitivity of the aquatic resource to mass wasting impacts. If, after field review and verification, questions still remain about high hazard slope stability, the reviewer will obtain approval of a professional geologist.

MRC will use all of this field analysis to determine if a proposed PTHP is compatible with our default conservation measures. If a PTHP is compatible, MRC will adopt the default conservation measures as our management plan for the project. If a PTHP is not compatible, MRC will either redesign the PTHP so that it is compatible with default conservation measures or append a report to the submitted PTHP by both a professional geologist and an individual knowledgeable in the relevant aquatic resources at risk.

Even if MRC proposes alternative conservation measures for a project, we must still address their risks to aquatic habitat and species. In effect, a professional geologist must prepare a report which evaluates key issues and concludes, based on a reasoned assessment of site conditions, that the proposed activities do not present a greater risk of sediment delivery from mass wasting than the default conservation measures. In addition, an individual knowledgeable in any relevant aquatic resources at risk must prepare a report. This individual will be an aquatic biologist, hydrologist, or fluvial geomorphologist—either an MRC employee or an outside consultant. The selected person must have knowledge of MRC biological monitoring, watershed analysis data, and the aquatic habitat or species in the area covered by the proposed alternative conservation measures. MRC will use the person best suited for the evaluation. For example, if mass wasting could affect the habitat of coastal tailed frogs, a biologist knowledgeable about these frogs will do the analysis. Likewise, if sediment aggradation in a Class I watercourse is blocking anadromous salmonid migration, a hydrologist or fluvial geomorphologist will examine the consequences of sediment delivery to the fluvial system. Most importantly, the professional geologist, the area manager, and the aquatic specialist must agree on the alternative proposal.

MRC intends to provide appropriate training to foresters that will allow them to identify hazards in the field—nothing more. If a forester identifies hazards in the field and the solutions proposed by management are in conflict with default conservation measures, a professional geologist and a person knowledgeable about the aquatic biological resources must perform a full assessment. Figure 8-12 outlines the decision-making process that MRC will use to determine the level of risk for mass wasting and sediment delivery.

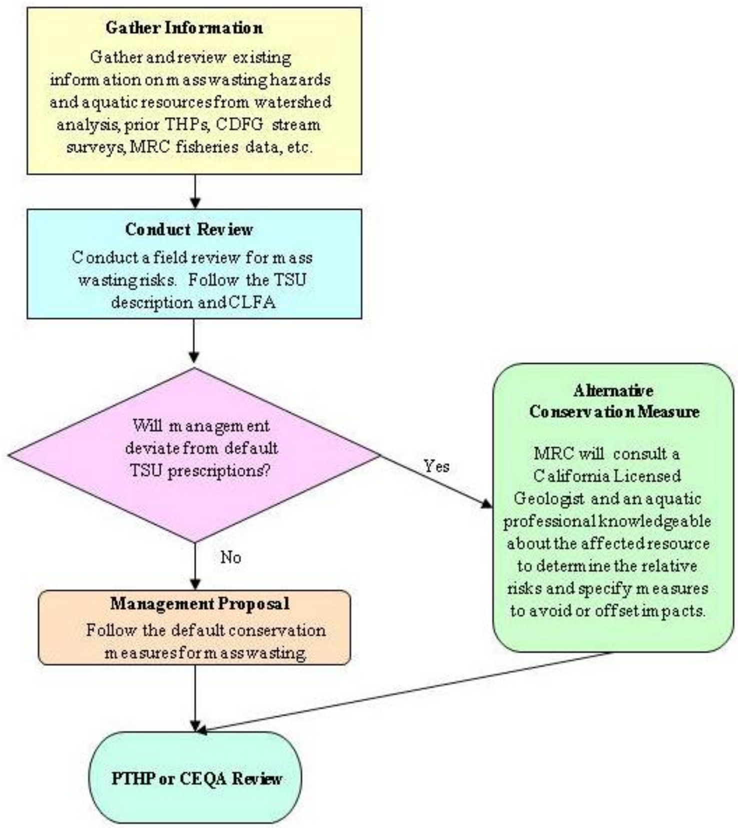


Figure 8-12 Decision Flow Chart for Mass Wasting Hazards

8.3.1.1.2 General description of TSUs and historically active landslides

Our HCP/NCCP refers to 8 TSUs, as well as historically active landslides (see HCP/NCCP Atlas, MAPS 5A-5C). The plan area has been intensively harvested over the past 100-150 years. During that time, numerous hydrologic events have also occurred which have triggered mass wasting. While problems created by management in the past persist today, it is also valuable to look at what did not happen—to look at actions of management that might have resulted in mass wasting or impacts to aquatic habitat but, in fact, did not. All of these observations help us to partition our land into areas of similar terrain stability.

Appendix G, *Watershed Analysis: Background and Methods*, contains illustrations and definitions of some of the geological terms used in the following descriptions and conservation measures for mass wasting, such as scarp, bench, and landslide.

TSU1

DEFINITION	**TSU1** is an area with steep slopes or inner gorge adjacent to low-gradient Class I and Class II streams.

An inner gorge can be isolated to one side of a stream channel. Steep channel banks are generally not considered inner gorge unless they extend upslope a minimum of 10 ft. The stream gradient is typically less than 6%.

The slope gradient within TSU1 is typically greater than 65% with planar slopes; concave slopes greater than 70% are the least stable. The upper extent of TSU1 is highly variable. Therefore, without a visible break in slope, only further field observation can define a TSU1. In some cases, the upslope boundary is defined by a prominent break in slope; this is classified as inner gorge (Figure 8-13). More often such a boundary is absent; this is classified as steep streamside slopes. Delineation of the upper boundary of steep streamside slopes is more subjective and based on professional judgment.[15] During terrain stability mapping, TSU1 is conservatively mapped as a continuous streamside unit; one factor considered in the delineation of the upper boundary of steep streamside slopes is the crown scarps of deliverable (or delivered) landslides to the watercourse transition zone. TSU1 captures shallow landslides typically found on steep slopes; these slides deliver sediment directly to a watercourse.

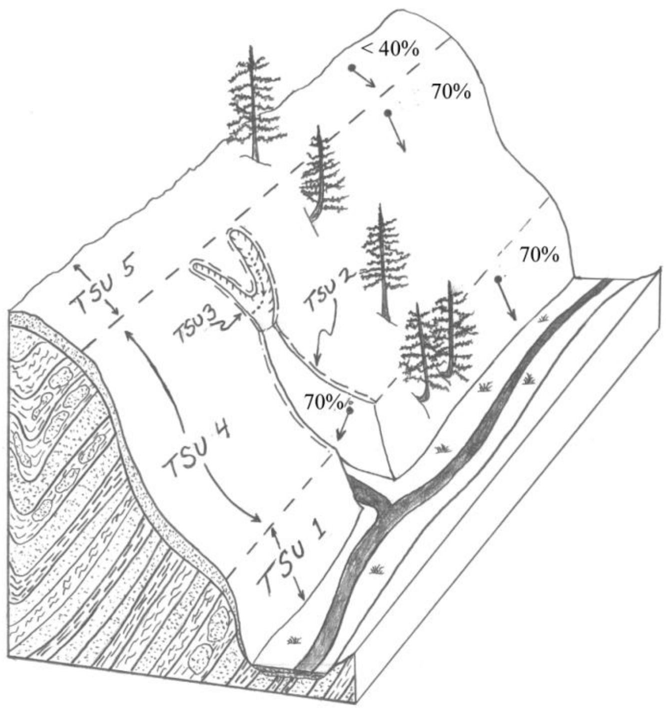


Figure 8-13 Defining TSU1

TSU2

DEFINITION	**TSU2** is an area with steep slopes or inner gorge adjacent to high gradient, intermittent or ephemeral Class II and Class III streams; the stream gradient is typically greater than 6%.

[15] Observations of past landslide activity within the general vicinity of a project area can help the reviewer determine the boundary definitions of TSU1 through TSU3. If, for example, an area has been intensively harvested and subjected to stressing storm events, and there are, as well, no crowns of old slides and no breaks in slope, the reviewer would likely not classify the area as a TSU1, 2, or 3 despite the steepness of slope. However, if there is evidence on gentler slopes than described in the TSU designation of landslides unrelated to roads and these landslides deliver to a watercourse, then the reviewer would classify the area as a TSU1, 2, or 3.

MRC intends to use this mapping unit when there is a high hazard for landslides along Class III or high-gradient Class II streams. While features and conservation measures are the same for TSU1 and TSU2, there are distinctions. TSU2 is, geologically, a more youthful topography with a higher gradient, more confined, stream channel; typically the streams are located higher in the watershed with a distinctly different aquatic habitat at risk.

TSU3

DEFINITION	**TSU3** is an area with primarily steep, convergent, and dissected topography located within steep swales or hollows.

Data from MRC watershed analyses suggests slopes are steep, typically greater than 70%. In addition, the slopes have been sculpted over geologic time by repeated debris slides. There is strong evidence of past landslides as well.

TSU3 does not constitute a continuous streamside unit, like TSU1 or TSU2. TSU3 usually represents isolated high-hazard areas. Headwall swale areas, or zero order swales, are found within TSU3. These are steep (> 70%) un-channeled swales located above Class III streams. Thick deposits of colluvium, which accumulate in the axis of the swale, may be the source for debris flows and torrents. Risk of sediment delivery from landslides is highly dependent upon local soil and bedrock properties, which are spatially variable in Franciscan geology; as such, the presence of past instability is usually an indicator of potential landslides.

TSU4

DEFINITION	**TSU4** is an area with moderate to moderately-steep hillslopes (typically 30-65%) with planar, divergent, or broadly convergent slope forms.

Steeper slopes (> 65%) may be present in this unit but show no evidence of instability or no means for sediment delivery should a landslide occur. TSU4 will occasionally contain areas of steep or strongly convergent slope forms or steep streamside slopes. Field visits can more accurately classify terrain into the appropriate TSU.

TSU5

DEFINITION	**TSU5** is an area with low gradient slopes (typically <30%), although locally steeper slopes may exist.

TSU5 occurs on broad ridge crests, low-gradient side slopes, and large low-gradient marine or river terraces. MRC intends to use this mapping unit to represent areas that have a very low risk of sediment delivery from landslides.

TSU6

DEFINITION	**TSU6** is an area with active or dormant earthflows or earthflow complexes.

TSU6 primarily occurs within Franciscan melange geology, which exists only in a few isolated locations in the plan area, e.g., Ackerman Creek. In addition to the risk for earthflow movement or initiation, TSU6 has a high likelihood of fluvial erosion or gullies when water is concentrated on soils.

During field visits, MRC may identify other TSUs in areas specified as TSU6. For example, areas of inner gorge along watercourses (TSU1 or TSU2) may suggest a very high risk for sediment delivery from landslides within TSU6. In these situations, MRC must weigh the considerations for each TSU, such as the processes for earth flow movement and shallow landslides, and implement the most protective conservation measures.

TSU7

DEFINITION	**TSU7** is an area within Franciscan melange geology that has accelerated creep not associated with any distinct earthflow or landslide.

There is a likelihood that earthflows or earthflow complexes could initiate in TSU7. In addition to the hazard for earthflow development, TSU7 has a high likelihood of fluvial erosion or gullies when water is concentrated on soils. This mapping unit can have similar topography and risk of landslides as TSU4. However, due to the higher rate of soil or rock creep, as well as weak-rock materials in the Franciscan melange geology, MRC classifies TSU7 as a separate map unit.

TSU8

DEFINITION	**TSU8** is a unique geological terrain with low gradient slopes (typically less than 30%) that have a very high potential for surface erosion.

TSU8 was delineated from published maps of outcrops in the Ohlsen Ranch Formation. This unit is white-gray, cohesionless, fine grained marine sandstone, which overlies the Franciscan in isolated locations without conformity. TSU8 has a low potential for slope failure because of its low gradient slopes. It has a high potential, however, for severe surface erosion if water is allowed to concentrate on roads, skid trails, and landings.

Historically active landslides

DEFINITION	**Historically active landslides** are areas which have undergone some type of movement within historic time (i.e., the last 100-150 years).

Historically active landslides are a subset of a TSU; as such, they are geographically smaller than a TSU. Our rationale for having a separate set of conservation measures for historically active landslides is to provide protection to portions of the landscape which have failed in the recent past and delivered sediment to a watercourse. Generally, because of the unfavorable geology and active tectonism of the Franciscan, the majority of the landscape has been shaped by mass wasting processes. Within the Franciscan, areas are more or less susceptible to mass failures and subsequent sediment delivery. The intention of our mass wasting strategy for historically active landslides is to acknowledge that there are locations where mass failures have historically occurred; without appropriate assessment, future failures will also occur that could result in sediment delivery to a watercourse.

Appendix J, *CLFA Checklist and Landslide Form*, gives the field indicators of historical activity. They generally fall into 4 categories:

- Topographic
  - Curved depressions
  - Hummocky ground
- Hydrologic
  - Disrupted drainage network
  - Seeps
  - Ponds
- Vegetative
  - Hydrophytes
  - Jackstrawed trees (tilted in various directions)
  - Linear strips of even aged trees
- Geologic/soils
  - Tension cracks
  - Anomalous erosion (gullies).

Typically, multiple indicators must be present to draw the conclusion that a landslide occurred in the last 100-150 years. Additionally, portions or blocks of a landslide may be historically active while other areas appear dormant. Our conservation strategy is conservative in that landslides are considered to be active if any portion of them shows signs of historical activity.

8.3.1.1.3 Use of TSUs

TSUs encompass all covered lands. In an effort to assess mass wasting hazards, MRC maps 8 TSUs, as well as landslides, during watershed analysis. Appendix G, *Watershed Analysis: Background and Methods* (section G.2.1.4), details the mapping methods. TSU maps are produced through reconnaissance mapping and ground truthing. They are similar to mapped soil series in that each TSU includes areas with different TSU values. Nevertheless, the scale at which MRC maps deep-seated landslides in watershed analysis cannot capture the subtleties of mountainous terrain.[16] Such maps are simply working hypotheses, confirmed or modified by foresters after field review. With new information, GIS generates new maps every 20 years for each watershed analysis. Moreover, GIS will update TSU maps as required and make them available for field staff.

Default conservation measures determine the land management applied to each TSU. Conservation measures apply only to specific terrain which fits a TSU description. For example, MRC may map steep streamside topography (TSU1) along a watercourse, but discover upon field review that isolated low-gradient terraces (TSU5) exist within the same area. These latter areas would then receive protections suitable for TSU5. Whenever there are competing conservation measures, MRC will use the conservation measure with the highest protection standards.

MRC has identified 2 deep-seated landslides in the plan area: earthflows and rockslides. Dormant earthflows are addressed in TSU6; active earthflows and rockslides are addressed in conjunction with the strategy for historically active landslides. A morphological feature created by a rockslide (toe, scarp, or body) may influence the classifications of TSU1 through TSU5. For example, MRC would classify areas in which over-steepened toes of a deep-seated landslide lie directly adjacent to a watercourse as one of the

[16] Typically MRC will use air photos (1:12,000 scale) and transfer the data to base maps (1:24,000 scale). The forester will also create a drainage map from an on-the-ground inspection at the project level.

streamside TSUs—TSU1 or TSU2. Likewise, if the crown or lateral scarps are over-steepened, MRC would map the area as steep mid-slope terrain—TSU3.

In MRC watershed analysis, rockslide maps are super-imposed over a TSU map. This is to ensure that we consider both the rockslide hazards and the terrain hazards. A person trained in identification of mass wasting features, TSUs, and risks of sediment delivery will evaluate the mapped landslides for historical activity, using the *CLFA Checklist* in Appendix J (section J.1), and determine the need for professional geologic review.

8.3.1.1.4 Training in mass wasting hazards

MRC will train our staff to identify unstable areas and risks of sediment delivery. A California Registered Geologist, knowledgeable in issues of both slope stability and forest management, will conduct the training. Any MRC employee who will perform field reconnaissance for unstable areas or TSU locations must attend training. The training program will be 2-tiered (Figure 8-14).

- Tier 1 of the program, required for all employees who will perform field reconnaissance and have not previously been trained, will focus on identification of unstable areas and risks of sediment delivery. The course will address (1) how to interpret watershed analysis and field information, including map review; (2) terminology; and (3) mass wasting attributes.

- Tier 2 of the program will offer a refresher course every 5-7 years to those who have completed Teir-1 training. It will review updates in terminology, regulations, and watershed analysis, as well as new research relevant to mass wasting hazards.

MRC will design the training program. In doing so, we will invite geologists from the wildlife agencies, the California Geological Survey, and the regional Water Quality Control Board to assist in its development and delivery. In addition, we will periodically query the wildlife agencies and other appropriate parties (including, but not limited to CGS and RWQCB) to determine if new knowledge should trigger a refresher course.

8.3.1.2 Roads, skid trails, and landings

Proper management of roads, landings, and skid trails is important to reduce sediment inputs; promote quality habitat for aquatic species; protect beneficial uses of water; provide efficient infrastructure for forest operations; extend protections to terrestrial wildlife species; and limit the introduction of invasive species and pathogens.

The MRC road strategy emphasizes assessment, upgrade, and repair of our roads, landings, and skid trails. Our roads are primarily for timber harvest and forest management with some recreational use. MRC will follow standards for road upgrades, maintenance, decommissioning, construction, and use. These standards apply to

- Road and landing construction and reconstruction.
- Road inspection and maintenance.
- Road and landing closure and decommission.
- Road use restrictions.
- Water drafting from watercourses or ponds.
- Design, construction, maintenance, decommissioning, and use of skid trails.

All of these standards are included in Appendix E, *Road, Landings, and Skid Trails*, and Appendix F, *Road Inventory Protocol*.

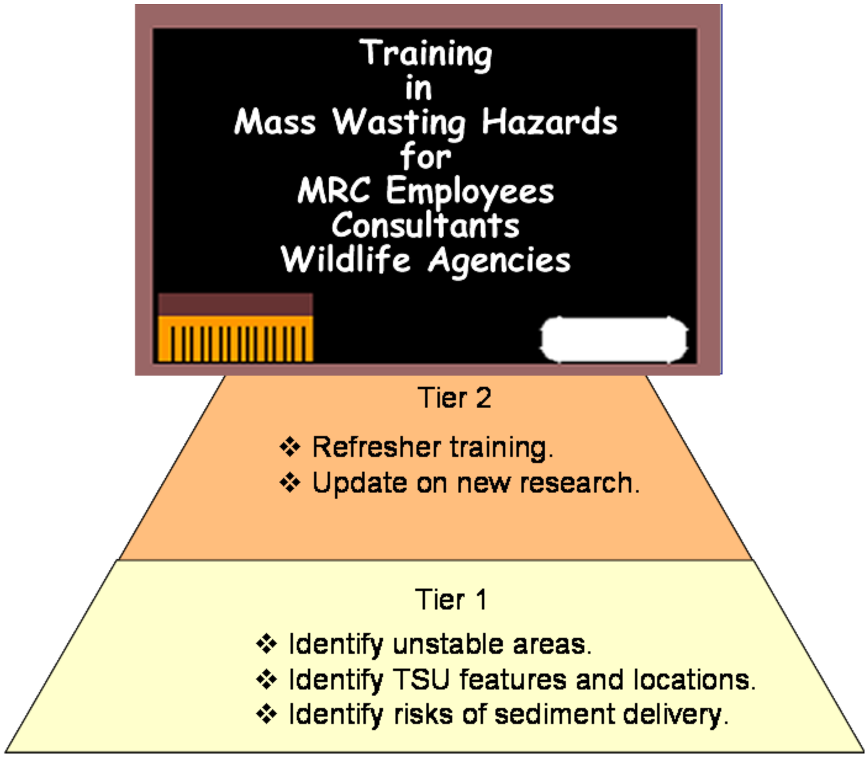


Figure 8-14 Training in Mass Wasting Hazards

Following the road standards in Appendix E, MRC will construct roads to facilitate harvests within the plan area. Historically, roads within the plan area were constructed near streams. Advancements in harvest methods now allow trees to be harvested uphill, away from stream zones, instead of downhill near the streams. This necessitates construction of roads upslope and decommissioning of roads near streams. With this re-designed road network, MRC expects that new road construction will slow down substantially within 20 years of HCP/NCCP commencement. By Year 40 of our HCP/NCCP, 95% of roads should be in place. MRC expects some new road construction throughout the term of our HCP/NCCP, however, as environmental factors and more advanced logging technology make new routes necessary.

8.3.1.2.1 Road inventory and information management

Road Inventory

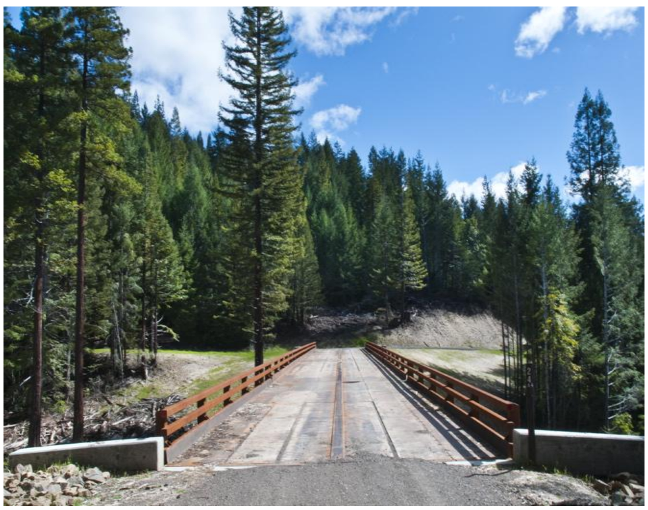
MRC has developed and implemented a road inventory program. It consists of a complete inventory of truck roads in the plan area. The inventory tracks roads and road features with a Global Positioning System (GPS). Road features include road segments, watercourse-crossings and structures (culverts, bridges, etc.), landings, erosion features, rock pits, gates, road slides, waterholes, and spoil piles. For each road feature, MRC has inventoried design specifications, such as dimensions, material type, road surface material, road prism, sediment delivery, and treatment immediacy. Appendix F, *Road Inventory Protocol*, provides further detail.

During our road inventory, MRC collects information on past sediment delivery for each road feature and its associated *controllable erosion*. Controllable erosion is a term developed by the North Coast Regional Water Quality Control Board for Total Maximum Daily Load (TMDL) purposes. It is a condition that could deliver soil to a watercourse during the next 40 years—the duration of a TMDL. Three important points qualify this definition of controllable erosion:

- Human action created the condition.
- Human action can, to a greater or lesser extent, control the condition.
- The condition, if uncontrolled, has the potential to deliver sediment.

Typically, controllable erosion is a measure of fill material in a road that could erode into a watercourse. During road inventory, MRC evaluates the required treatment for all sites with controllable erosion. In addition, MRC inventories any potential diversion for crossings or drainage structures.

In 2011, the MRC road inventory was approximately 90% complete; we will complete the road inventory by the end of 2012 (see Table 7-3). The road inventory will be ongoing and all roads with permanent structures (culverts or bridges) will be re-inventoried within a 10-year interval (2020, 2030, 2040, etc.). The re-inventory effort will update the information on new roads and changes to existing roads and provide an ongoing inspection of the entire MRC road network.



Camp Creek Bridge (Navarro East Watershed) was designed by Morris Engineering Co. and completed by Skip Gibbs Co. in October 2010. The MRC Navarro Road Department (NRD) removed 20,000 yds^3 of dirt (24,300 tons) to replace the old culvert crossing. The distance from bridge deck to the stream is about 40 ft—about the same as for Little Jack Creek Bridge (pictured below) as well.

Before construction of Little Jack Creek Bridge, the bottom of the culvert was rusted out and a fish barrier. The MRC NRD cleared away 12,000 yds^3 of dirt (14,580 tons) for the bridge.

Little Jack Creek Bridge Completed October 2010
Little Jack Creek is a tributary of North Fork Navarro River, a designated "coho core area."

Road information management

MRC will retain information from our road inventory in a database. There will be updates to the database when (1) road work or repairs alter road segment or road site characteristics; (2) maintenance of a road alters road segment or road site characteristics; and (3) monitoring of roads require sites to have treatment priority changed.

These updates will occur at least once a year. In addition to new information and updates, the database will warehouse all historical information on roads, their features, roadwork, and dates of improvements. Through our database, MRC can track and report past and present conditions and improvements.

Watershed analysis and prioritization of road upgrades

Watershed analysis includes road inventory information. This analysis is repeated, on average, every 20 years. From this analysis, MRC prioritizes roads and sites for upgrade, decommissioning, or special maintenance. This prioritization is based on the amount of controllable erosion of a site; the immediacy of treatment required; the risk to aquatic habitat; the risk to beneficial uses of water; hazard ratings; and potential for diversion. MRC takes all of these factors into consideration along with the THPs for any given year, as well as our plans for road upgrades commensurate with THPs. This is important for both economic and environmental reasons. Opening up a long stretch of road to fix 2 or 3 high erosion sites can cause substantial ground disturbance. In some cases, it is better to fix all the erosion sites on the entire road at one time, no matter what their priority status. This would allow the road to be undisturbed until the next harvest operation. Planning for road repairs while other operations are ongoing localizes the disturbance rather than extending and prolonging it.

8.3.1.2.2 Training in repair of controllable erosion

Trained individuals will repair MRC roads and skid trails. MRC will provide this training to coincide with assessment training for mass wasting hazards. Any MRC employee who will perform field reconnaissance for controllable erosion must attend the training. The training program will be 2-tiered years (Figure 8-15).

- Tier 1 of the program, required for all employees who will perform field reconnaissance and have not previously been trained, will focus on identification of controllable erosion sites on roads and skid trails. The course will address how to (1) interpret the terminology in the road inventory system; (2) identify and collect road data; and (3) submit annual data for the road inventory. In addition, training will include 1 day of field visits to pre- and post-repair sites for controllable erosion.

- Tier 2 of the program will offer a refresher course every 5-7 years to those who have completed Teir-1 training. It will review updates in terminology, regulations, and road repair procedures.

MRC will design the training program. In doing so, we will invite geologists from the wildlife agencies, the California Geological Survey, and the regional Water Quality Control Board to assist in its development and delivery. In addition, we will periodically query the wildlife agencies and other appropriate parties (including, but not limited to CGS and RWQCB) to determine if new knowledge should trigger a refresher course.

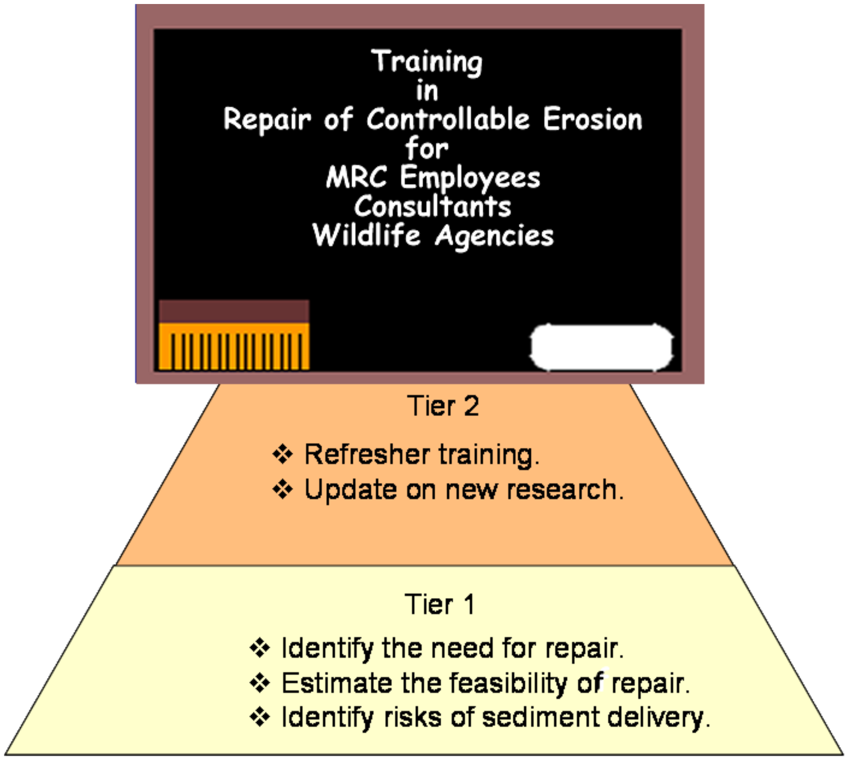


Figure 8-15 Training in Controllable Erosion

8.3.1.3 Instream sediment

Suspended sediment in streams affects water quality and, therefore, the viability and productivity of aquatic populations. Flowing with the current, fine particles create turbidity. Some of these particles deposit on the streambed causing loss of benthic productivity and fish habitat. Young salmon and trout, for example, hide in interstitial spaces between rocks to avoid predation. If fine sediment clogs these interstitial spaces, juvenile salmonids may lose their source of cover and food. Likewise, increased sediment in spawning gravels may decrease survival of salmonid eggs and alevin.

8.3.2 Goals and Objectives

Goal and Objectives for Sediment Input	
Goal	
G§8.3.2-1	Reduce sediment delivery from forest management to (1) promote high quality habitat for covered anadromous salmonid and amphibian species and (2) protect other beneficial uses of water.
Objectives	
Mass Wasting Unrelated to Roads	
O§8.3.2-1	Reduce, by year 40 of the HCP/NCCP, sediment delivery from mass wasting unrelated to roads by at least 10% of the rate (tons/mi^2/year) determined in the initial watershed analyses or established in TMDL load allocation reductions. [17]

[17] Each watershed analysis report located on the MRC website at http://www.mrc.com/Reports-WatershedAnalysis.aspx and on the California State Water Resources Control Board website at http://www.swrcb.ca.gov/water_issues/programs/tmdl/#rb1 contains estimates of erosion rates for specific watersheds.

Goal and Objectives for Sediment Input	
O§8.3.2-2	Reduce, within the 80-year timeframe of the HCP/NCCP, sediment delivery from mass wasting unrelated to roads by at least 20% of the rate (tons/mi^2/year) determined in the initial watershed analyses or established in TMDL load allocation reductions.
Roads, Skid Trails, and Landings	
O§8.3.2-3	Reduce, by year 40 of the HCP/NCCP, sediment delivery from mass wasting related to roads by at least 30% of the rate (tons/mi^2/year) determined in the initial watershed analyses or established in TMDL load allocation reductions.
O§8.3.2-4	Reduce, within the 80-year timeframe of the HCP/NCCP, sediment delivery from mass wasting related to roads by at least 60% of the rate (tons/mi^2/year) determined in the initial watershed analyses or established in TMDL load allocation reductions.
O§8.3.2-5	Upgrade, within the first 30 years of the HCP/NCCP, the road network in the plan area to the standards specified in Appendix E, *Roads, Landings, and Skid Trails;* complete upgrades to the road network in coho "core" areas within the first 20 of those 30 years.
O§8.3.2-6	Control 1,302,000 yd^3 of controllable erosion within the first 30 years of the HCP/NCCP. **NOTE** The total amount of controllable erosion may change due to road inventory updates and weather.
O§8.3.2-7	Reduce point source erosion from roads, skid trails, or landings and sediment delivery associated with surface erosion by 50% within the first 30 years of the HCP/NCCP (i.e., from 4000 to 2000 yd^3 per mi^2 per year) and 70% within the initial 70 years of the HCP/NCCP (i.e., from 4000 to 1200 yd^3 per mi^2 per year).
Instream Sediment	
O§8.3.2-8	Demonstrate an improving trend in the following parameters over the life of the HCP/NCCP based on MRC conducting (a) watershed analyses at least every 20 years, (b) long-term channel monitoring every 10 years, and (c) focus watershed studies every 3-5 years: ▪ Quality of stream gravel as measured by increased permeability and percent of fine particles < 0.85 mm. ▪ Stream-reach complexity as measured by residual pool depths and standard deviation of residual pool depths within long-term stream monitoring reaches. ▪ Proportion of fine sediment in pools (V-star). ▪ Decreased sediment inputs to the sediment budget for focus watersheds. **NOTE** 1. MRC has not set benchmarks for instream sediment objectives since rarely do management activities unambiguously or expressly impact instream habitat conditions. 2. Stream gravel permeability will approximate, on average, 10,000 cm/hr across stream reaches. 3. The percent of fine material < 0.85 mm, recovered from dry sieve techniques, will approximate, on average, < 7% across stream reaches. 4. The fraction of pool volume filled with fine sediment should average ≤ 0.21 across stream reaches.

Goal and Objectives for Sediment Input	
O§8.3.2-9	Demonstrate an improving trend in the turbidity and suspended sediment.

8.3.3 Conservation measures

8.3.3.1 Mass wasting

This section details the conservation measures that MRC will apply to minimize sediment delivery and subsequent damage to aquatic habitat. The conservation measures are organized by TSU and historically active landslides. In these conservation measures, we address

- Construction or reconstruction of roads and landings.
- Use of existing roads and landings.
- Construction or reconstruction of tractor trails.
- Tractor yarding.
- Timber harvest.
- Site preparation.

At the end of each section on TSU conservation measures, there is a summary of the expected even-aged regeneration harvests of stands that may occur within each TSU over the next 30 years; this is consistent with the expected time frame to restore poorly stocked stands to conifer dominance. To generate our data, we superimposed a TSU layer over stand data in our landscape model. The stand data relates to specific stands that will be subjected to even-aged regeneration harvests in an effort to restore them to conifer dominance.

An important point to keep in mind in reviewing estimates of acreage on TSU maps is that the numbers precede field verification at the PTHP scale. Typically throughout the mapping process, areas of predicted instability are conservatively mapped and potential impacts likely overestimated. Additionally, since TSU mapping is not complete on our land, the estimates are indicative of about 70% of the plan area or nearly 150,000 ac. Since terrain stability and stand conditions are variable, the estimates probably cannot be extrapolated to the remaining 30% of the plan area.

Any acreage subject to a regeneration harvest for even-aged stands is also subject to conservation measures for its related TSU. For instance, any regeneration step to produce even-aged stands in TSU1 is subject to geologic and biologic review by regulating agencies; there must be documented evidence to support any proposed activity. The 5% alternative, discussed in section 8.3.4.5, provides minimal flexibility to the foresters; in those instances, they can implement a regeneration harvest for even-aged stands in areas of potential instability without the use of geologic and biologic review.

We have not provided estimates of acres of even-aged management on historically active landslides; these areas are delineated during the field review of the PTHP process.

8.3.3.1.1 Deviation from default conservation measures for mass wasting

In some instances, MRC may resort to geological and biological assessments in order to deviate from default conservation measures for mass wasting. Any such deviation must still conform to the limits specified in this sub-section and to guidelines such as Note 45 of the California Division of Mines and Geology. There will not be a reduction of the standard silviculture within an AMZ for these deviations; rather they will occur within the TSU outside of the AMZ. A California licensed geologist must evaluate key issues and conclude based on standard assessments of site conditions that when there is potential for sediment delivery the proposed activities do not present a greater risk of such delivery from mass wasting than the default conservation measures. MRC will notify the wildlife agencies and CGS 60 days prior to submittal of a PTHP that proposes new road construction within an inner gorge and 30 days for road reconstruction within an inner gorge. Notification will include a report submitted by a California PG/CEG of their investigation, evaluations, and recommendations according to Note 45 guidelines. The wildlife agencies will contact MRC within either the 30 or 60 days of receipt of notification to resolve any of their concerns. If the wildlife agencies do not contact MRC within either the 30 or 60 days, MRC may proceed with the proposed activities. MRC will include all geologist evaluations for review by the wildlife agencies within the PTHP and note the frequency of all deviations from conservation measures in annual reports.

8.3.3.1.2 TSU1 and TSU2

INTENT	The intent of the conservation measures for TSU1 and TSU2 is to minimize management actions that increase the potential for sediment delivery from mass wasting on inner gorge and steep streamside slopes. When natural mass wasting processes occur, the conservation measures ensure that trees will be available for delivery to watercourses to mitigate sediment delivery and provide habitat for aquatic organisms.

Inner gorge[18] topography of TSU1 and TSU2

	Conservation Measures for TSU1 and TSU2 Inner Gorge
Roads	
C§8.3.3.1.2-1	Do not construct or reconstruct roads or landings.
C§8.3.3.1.2-2	Do not construct watercourse crossings.
C§8.3.3.1.2-3	Decommission existing roads and landings when they are no longer needed. **NOTE** If relocation of a road poses a higher risk of sediment delivery than maintenance and use of an existing road, MRC will maintain the road to the design standards specified in Appendix E, *Roads, Landings, and Skid Trails*.
Tractor Trails	
C§8.3.3.1.2-4	Do not construct tractor trails.
Tractor Yarding	
C§8.3.3.1.2-5	Exclude equipment.
Timber Harvest	
C§8.3.3.1.2-6	Do not harvest timber.
C§8.3.3.1.2-7	Maintain ≥ 50% canopy on slopes which contribute surface or subsurface flow to the inner gorge.[19]
Site Preparation and Burning	
C§8.3.3.1.2-8	Do not permit site preparation or burning.

[18] Inner gorge conservation measures extend 25 ft beyond the break in slope.

[19] MRC will initially determine these slopes targeted for canopy retention using a 1:24,000 topographic base map. We will interpret the topographic lines as lines of equipotential. Flow lines which cross equipotentials at right angles will depict the likely flow of surface or subsurface water downslope to the inner gorge. In the field, we may do further delineation of the area topographically contributing to the inner gorge including anthropogenic diversions of watercourses. This conservation measure will be applied to Class I and Large Class II watercourses.

Deviation from default conservation measures for inner gorge

	Limits on Deviation from Default Conservation Measures in TSU1 and TSU2 Inner Gorge
C§8.3.3.1.2-9	Retain at least 70% canopy (averaged throughout the inner gorge) and at least 15 ft^2 of conifers ≥18 in. dbh per acre.
C§8.3.3.1.2-10	Ensure that trees are evenly dispersed across the slope after a timber harvest, unless an assessment reveals, from the presence of competent bedrock, that the inner gorge is in fact stable, in which case MRC will retain more trees on the least stable areas.
C§8.3.3.1.2-11	Allow construction and reconstruction of roads, skid trails, and landings within inner gorges only after notification to the wildlife agencies and review by a geologist.

Steep streamside slopes of TSU1 and TSU2

	Conservation Measures for TSU1 and TSU2 Steep Streamside Slopes
Roads	
C§8.3.3.1.2-12	Do not construct new roads or landings.
C§8.3.3.1.2-13	Do not construct watercourse crossings.
C§8.3.3.1.2-14	Adhere to the standards in Appendix E, *Roads, Landings, and Skid Trails*, for reconstructed roads.
C§8.3.3.1.2-15	Decommission existing roads and landings when they are no longer needed. **NOTE** If relocation of a road poses a higher risk of sediment delivery than maintenance and use of an existing road, MRC will maintain the road to the design standards specified in Appendix E, *Roads, Landings, and Skid Trails*.
Tractor Trails	
C§8.3.3.1.2-16	Do not construct tractor trails.
Tractor Yarding	
C§8.3.3.1.2-17	Permit equipment on existing stable trails where other yarding methods could pose a greater risk of sediment delivery to a watercourse or where one-time entry into the TSU is required to control erosion.
Timber Harvest	
C§8.3.3.1.2-18	Retain at least 50% overstory canopy in those portions of the unit that extend above the AMZ.[20]

[20] MRC included this conservation measure to prevent potential mass wasting hazards on soil with increased moisture (see section 8.3.2.14). Observations of past landslide activity within the general vicinity of a project area can help the reviewer determine the boundary definitions of TSU1 through TSU3 (see section 8.3.1.1.2).

	Conservation Measures for TSU1 and TSU2 Steep Streamside Slopes
C§8.3.3.1.2-19	Retain at least 15 ft^2 of conifers ≥18 in. dbh per acre, with trees evenly distributed across the slope in those portions of the unit that extend above the AMZ.[21] **NOTE** The 20 ft reduction on the middle band of the AMZ for helicopter or cable yarding applies only when the AMZ extends **beyond** TSU1 and TSU2 and not when the AMZ is **within** these TSU units. Expected regeneration harvest for even-aged stands on TSU1: 123 ac (Years 0-15); 82 ac (Years 15-30). Expected regeneration harvest for even-aged stands on TSU2: 642 ac (Years 0-15); 254 ac (Years 15-30).
Site Preparation and Burning	
C§8.3.3.1.2-20	Do not permit site preparation or burning.

Deviation from default conservation measures for steep streamside slopes

	Limits on Deviation from Default Conservation Measures in TSU1 and TSU2 Steep Streamside Slopes
C§8.3.3.1.2-21	Permit new construction of roads, skid trails, and landings only after a review and site specific design by a PG or CEG.
C§8.3.3.1.2-22	Permit reconstruction of roads, skid trails, and landings across unstable areas within TSU1 or TSU2 (i.e., steep streamside slopes) only after obtaining approval of the wildlife agencies as well as a review and site specific design by a PG or CEG.
C§8.3.3.1.2-23	Ensure that trees are evenly dispersed across the slope after a timber harvest in TSU1 and TSU2.
C§8.3.3.1.2-24	Permit a one-time use of shelterwood and seed-tree removal steps outside the inner and middle bands of an AMZ, as long as MRC retains 50% overstory canopy. **NOTE** 1. Seed-tree removal will not be a deviation from default conservation measures if it retains 50% overstory canopy and at least 15 ft^2 of conifers ≥ 18 in. dbh per acre, with the trees evenly distributed across the slope. 2. Use of shelterwood or seed-tree removal steps does not preclude the requirement for wildlife trees in the AMZ. MRC will not retain, for this one time entry, 15 ft^2 of conifers ≥18 in. dbh per acre.

[21] MRC included this conservation measure to allow for recruitment of adequate LWD in the event that mass wasting does occur (see section 8.2.4.7). Our best professional judgment determined the specified tree sizes.

8.3.3.1.3 TSU3

INTENT

The intent of conservation measures for TSU3 is to create a low risk of sediment delivery from management actions on steep and dissected slopes. In the event that mass wasting occurs, the conservation measures ensure that trees will be available for delivery to a watercourse to mitigate sediment delivery and provide habitat for aquatic organisms.

	Conservation Measures for TSU3 Steep Dissected Topography
Roads	
C§8.3.3.1.3-1	Do not construct or reconstruct a road to extend more than 50 ft across a headwall swale, excluding watercourse crossings.
C§8.3.3.1.3-2	Decommission existing roads and landings when they are no longer necessary. **NOTE** If relocation of a road poses a higher risk of sediment delivery than maintenance and use of an existing road, MRC will maintain the road to the design standards specified in Appendix E, *Roads, Landings, and Skid Trails*.
Tractor Trails	
C§8.3.3.1.3-3	Do not construct or reconstruct tractor trails.
Tractor Yarding	
C§8.3.3.1.3-4	Permit equipment on existing stable trails where other yarding methods could pose a greater risk of sediment delivery to a watercourse or where one-time entry into a TSU is required to control erosion.
Timber Harvest	
C§8.3.3.1.3-5	Retain 50% overstory canopy and, per acre, 15 ft^2 of conifers ≥ 18 in. dbh, distributed evenly across the TSU.
C§8.3.3.1.3-6	Emphasize tree retention in the axis of headwall swales where pore water pressures are typically greatest. Expected regeneration harvest for even-aged stands on TSU3: 3156 ac (Years 0-15); 1339 ac (Years 15-30).
Site Preparation and Burning	
C§8.3.3.1.3-7	Do not permit site preparation or broadcast burning.

Deviation from default conservation measures for steep dissected topography

	Limits on Deviation from Default Conservation Measures in TSU3 Steep Dissected Topography
C§8.3.3.1.3-8	Permit a one-time use of shelterwood and seed-tree removal steps outside the inner and middle bands of an AMZ. **NOTE** 1. Seed-tree removal will not be a deviation from default conservation measures if it retains 50% overstory canopy and at least 15 ft^2 of conifers ≥ 18 in. dbh per acre, with the trees evenly distributed across the slope. 2. Use of shelterwood or seed-tree removal steps does not preclude the requirement for wildlife trees in the AMZ. MRC will not retain, for this one time entry, 15 ft^2 of conifers ≥18 in. dbh per acre.
C§8.3.3.1.3-9	Retain 50% overstory canopy on headwall swales.
C§8.3.3.1.3-10	Permit new construction of roads, skid trails, and landings only after a review and site specific design by a PG or CEG.
C§8.3.3.1.3-11	Permit reconstruction of roads, skid trails, and landings across unstable areas within TSU1 or TSU2 (i.e., steep streamside slopes) only after obtaining approval of the wildlife agencies as well as a review and site specific design by a PG or CEG.

8.3.3.1.4 TSU4 and TSU5[22]

INTENT

The intent of conservation measures for TSU4 and TSU5 are to create a low risk of sediment delivery from management actions that might cause mass wasting on convex, moderate-to-gentle gradient hillslopes.

	Conservation Measures for TSU4 and TSU5 Non-dissected, Low Relief Topography
Roads	
C§8.3.3.1.4-1	Construct and maintain roads and landings to the design standards set out in Appendix E, *Roads, Landings, and Skid Trails*.
Tractor Trails	
C§8.3.3.1.4-2	Construct and maintain tractor trails to the design standards set out in Appendix E, *Roads, Landings, and Skid Trails.*
Tractor Yarding	
C§8.3.3.1.4-3	Limit tractor yarding to the fewest number of trails necessary to conduct yarding operations.

[22] The difference between TSU4 and TSU5 is that there is a moderate risk of mass wasting in TSU4 and little or no risk in TSU5. Prior to project initiation, MRC emphasizes that there must be field reviews in TSU4 for areas that should be classified as TSU1, TSU2, or TSU3. MRC will also focus on issues surrounding road construction and tractor yarding to minimize mass wasting in TSU4.

8.3.3.1.5 TSU6

INTENT

The intent of conservation measures for TSU6 is to avoid creating or accelerating movement of earthflows or earthflow complexes, or inducing gully erosion on earthflow complexes. This will ensure there is a low risk of sediment delivery from management actions that might cause mass wasting on earthflows. TSU6 is meant to address earthflows and earthflow complexes which show no evidence of historical activity.

Conservation Measures for TSU6 Earthflow Complexes[23]	
Roads	
C§8.3.3.1.5-1	Do not construct new roads on an earthflow complex.
C§8.3.3.1.5-2	Maintain roads and landings so that water is not concentrated on slide materials.
C§8.3.3.1.5-3	Do not increase or create cuts into a slide body or place fill material on a slide body, except for normal road maintenance.
Tractor Yarding	
C§8.3.3.1.5-4	Minimize new tractor trails and avoid disruption from equipment to the natural drainage of the earthflow.
Timber Harvest	
C§8.3.3.1.5-5	Retain ≥50% canopy, distributed across the TSU. Expected regeneration harvest of even-aged stands on TSU6: 42 ac (Years 0-15); 63 ac (Years 15-30).
Site Preparation and Burning	
C§8.3.3.1.5-6	Do not disturb the existing overstory canopy or disrupt drainage with heavy equipment for site preparation.

8.3.3.1.6 TSU7[24]

INTENT

The intent of conservation measures for TSU7 is to avoid gully erosion or the movement of debris slides, rockslides, earthflows, or earthflow complexes. The measures will ensure a low risk of sediment delivery from management actions in this accelerated-creep terrain.

Conservation Measures for TSU7 Accelerated Creep Terrain	
Roads	
C§8.3.3.1.6-1	Avoid water concentration on soils in order to prevent gully erosion.
Tractor Trails	

[23] MRC will consult a professional geologist prior to any work on an earthflow, except for road use or maintenance.
[24] The risk for sediment delivery from mass wasting is less in TSU7 than in TSU6. This is because earthflow or earthflow complex morphology is not apparent in TSU7. As a result, the likelihood of triggering or accelerating an earthflow or landslide is considerably less.

Conservation Measures for TSU7 Accelerated Creep Terrain	
C§8.3.3.1.6-2	Maintain, construct, and reconstruct tractor trails so that they do not increase the risk of mass wasting.
Tractor Yarding	
C§8.3.3.1.6-3	Avoid water concentration on soils in order to prevent gully erosion.
Timber Harvest	
C§8.3.3.1.6-4	Retain, on average, 50% canopy that is evenly distributed across the forested portion of the TSU.
Site Preparation and Burning	
C§8.3.3.1.6-5	Do not disturb existing overstory or disrupt drainage with heavy equipment during site preparation.

8.3.3.1.7 TSU8

INTENT

The intent of the conservation measures for TSU8 is to avoid concentration of road drainage which could lead to gully development and the delivery of fine sediment to a watercourse.

Conservation Measures for TSU8 Ohlsen Ranch Formation	
Roads and Tractor Trails	
C§8.3.3.1.7-1	Manage all roads and skid trails with a risk of sediment delivery as "extreme" erosion hazards regardless of their slope gradient.
C§8.3.3.1.7-2	Reduce the spacing between waterbars and rolling dips to 50 ft in order to minimize the concentration of water on a traveled surface.
C§8.3.3.1.7-3	Slash pack or mulch outlets of waterbars and rolling dips to dissipate the energy of concentrated surface run-off and minimize the likelihood of gully development.

8.3.3.1.8 Historically active landslides

INTENT

The intent of the conservation measures for historically active landslides is to minimize impacts that could reactivate a landslide. In the event that reactivation occurs, the conservation measures ensure that trees will be available for delivery to a watercourse to mitigate sediment delivery and provide habitat for aquatic organisms.

Conservation Measures for Historically Active Landslides	
Roads	
C§8.3.3.1.8-1	Do not construct or reconstruct roads or landings.
C§8.3.3.1.8-2	Maintain existing roads so that excessive water is not concentrated onto slide materials.
Tractor Trails	
C§8.3.3.1.8-3	Do not construct tractor trails.
C§8.3.3.1.8-4	Avoid concentration of excessive water drainage from skid trails on rockslide materials.

	Conservation Measures for Historically Active Landslides
Tractor Yarding	
C§8.3.3.1.8-5	Limit equipment to existing stable trails or roads.
Timber Harvest	
C§8.3.3.1.8-6	Do not harvest timber.
Site Preparation and Burning	
C§8.3.3.1.8-7	Do not permit heavy equipment for site preparation.
C§8.3.3.1.8-8	Limit equipment on dormant landslides to existing stable trails or roads.

Deviation from default conservation measures for historically active landslides

	Limit for Deviation from Default Conservation Measures Historically Active Landslides
C§8.3.3.1.8-9	Retain at least 50% canopy with trees evenly dispersed across the historically active landslide.

8.3.3.2 Roads, skid trails, and landings

While necessary for forest and wildlife management, roads may fragment terrestrial habitat and lead to modified animal behavior. Roads may be a source of harassment for some animals and a source of attraction for others. In fact, roads and their adjacent surroundings may qualify as a distinct habitat for species of birds and animals that live and thrive on the road edge. In addition, roads may contribute sediment to nearby streams and thereby threaten aquatic habitat. There is always, as well, an inherent danger to wildlife from vehicles travelling on roads. Even rare plants, near the road edge, may be crushed by truck tires.

While we are not proposing specific conservation measures for roads and road habitat, many of our conservation measures set restrictions on road use and reference our road standards, described fully in Appendix E, *Road, Landing, and Skid Trail Standards*. In the following sub-sections, we describe some of those standards, particularly as they relate to covered species and their habitat.

8.3.3.2.1 Road upgrade and controllable erosion repairs

MRC will upgrade roads to the standards outlined in Appendix E, *Roads, Landings, and Skid Trails*, and repair controllable erosion sites; we will decommission roads that are no longer needed. MRC will use the following criteria, which take into account the greatest risks to covered species and beneficial uses of the water, to prioritize road repairs for controllable erosion:

1. Artificial barriers to fish passage.
2. Risk of imminent failure.
3. Size of controllable erosion volume.
4. Watersheds that contain coho salmon and other sensitive aquatic species.
5. Sediment delivery receptor (Class I or Class II are highest priority).
6. Crossings within fire affected areas.
7. Immediacy of site treatment.
8. Priority of road or road site for repair from watershed analysis.
9. Culvert sizing (watercourse culverts are higher priority than ditch relief culverts).
10. Timing of adjacent harvest operations and availability of equipment.

11. Distance from other sites. (For example, if a low-priority site is located next to a high-priority site, they may be fixed simultaneously to save time and money.)
12. Risk of sediment delivery from the proposed treatment.
13. Cost effectiveness of the treatment, defined as less than \$19 per yd^3 of sediment controlled (in 2011 dollars).[25]

Each of the criteria is a priority for road sediment control work; however, multiple criteria will influence a site's prioritization. Figure 8-16 shows 2 examples of how the criteria determine the priority for maintenance. The size of the culvert is less important than its potential for delivering sediment to a stream and impacting aquatic species.

Using a baseline road inventory, MRC assigns treatment priorities (high, moderate, low) to controllable erosion sites. Table 8-17 stratifies these estimates of controllable erosion by priority designation within the watershed analysis units. MRC may accelerate repair of controllable erosion through increased effort or grant-funded projects. This acceleration could alter the amount of controllable erosion targeted for repair.

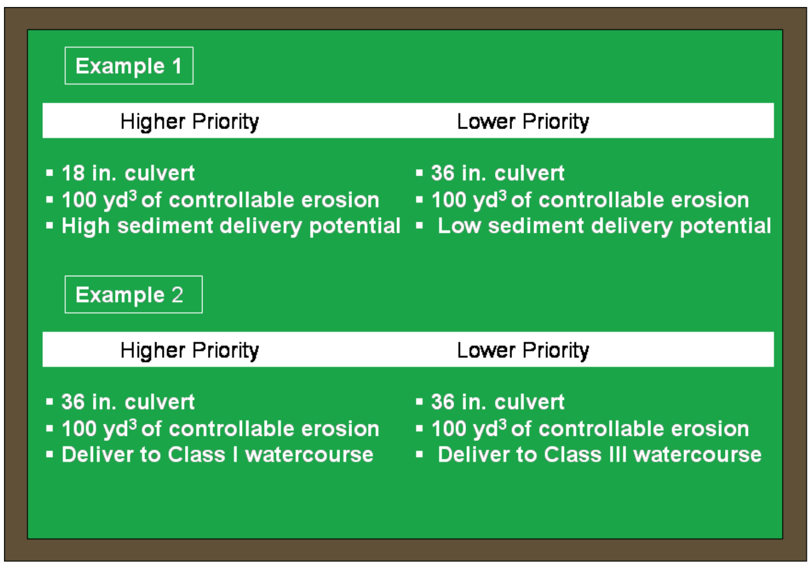


Figure 8-16 Examples of Prioritization

Our initial estimates are for units where road inventory is complete, which, in 2011, represents about 90% of the plan area. To extrapolate this volume (V) of controllable erosion to the remainder of the plan area, we took the initial estimates (I) and subtracted the controllable volume from Masonite Road (M)[26]— approximately 513,300 yd^3— as shown in the following equation:

$$(I - M) * 1/0.90 = V$$

$$(1{,}222{,}300\ yd^3 - 513{,}300\ yd^3) * 1/0.90 = 787{,}778\ yd^3$$

[25] MRC used a 2002 dollar amount from a CDFG review process for road work grants (\$15) and adjusted for 24.35% cumulative inflation since 2002 based on www.inflationdata.com. The result was \$18.65 rounded up to \$19. We use this dollar amount for a rule of thumb to set priorities, not as an absolute trigger for decision-making.

[26] We do not extrapolate results from Masonite Road to the remainder of our land because Masonite Road is unique and does not represent the rest of our roads. Instead we extrapolate all other data then add the Masonite Road totals to a total estimate for all MRC timberland.

We then added the volume of controllable erosion for Masonite Road (M) to the extrapolated volume (V) to obtain total volume (T) of controllable erosion or approximately 1,302,000 yd^3.

$$M + V = T$$

$$513{,}300\ yd^3 + 787{,}778\ yd^3 = 1{,}301{,}078\ yd^3 \approx 1{,}302{,}000\ yd^3$$

Table 8-17 Controllable Erosion Estimates (2011)

Watershed Analysis Unit (WAU)	Treatment Priorities and Volumes (yd^3)		
	High	Moderate	Low
Albion	3,100	1,900	11,800
Big River	97,200	130,300	68,800
Rockport	47,100	19,700	63,300
Elk Creek	2,200	900	14,700
Greenwood Creek	6,600	6,400	30,300
Garcia River	29,100	8,900	84,800
Navarro River	157,100	105,600	189,500
Northern Russian River	20,700	44,600	34,500
Noyo River	13,000	8,900	21,300
Total	376,100	327,200	519,000
Initial Estimate (I)	1, 222,300 yd^3		

8.3.3.2.2 Coho "core" watersheds

During the first 20 years of HCP/NCCP implementation, MRC will treat controllable erosion sites which (a) have a high or moderate priority and (b) are within coho "core" watersheds (see Appendix Z, *Coho Recovery Strategies*). CDFG, NMFS, and MRC have identified these watersheds as sensitive coho salmon areas with a high potential for restoration (see Table Z-1, *MRC Coho Core Areas*). Our HCP/NCCP Atlas (MAPS 26A-C) shows the locations of these watersheds. Within 10 years of HCP/NCCP implementation, MRC will treat at least 70% of the controllable erosion sites with a high priority and 50% of the sites with a moderate priority. We will treat the remainder of the high and moderate priority sites in coho core watersheds by Year 20 of HCP/NCCP implementation and all low priority sites by Year 40 (Tables 8-18 and 8-19).

8.3.3.2.3 Other watersheds

Outside the coho core watersheds, MRC will treat controllable erosion sites commensurate with our routine operations. MRC will, at a minimum, treat 1/3 of the controllable erosions sites with high and moderate priorities every 10 years. As a result, MRC will treat all high and moderate sites by Year 30 of HCP/NCCP implementation and all low priority sites by Year 40 (Tables 8-18).

Table 8-18 Percentage of Controllable Erosion Treated Per Decade in the Plan Area

Controllable Erosion							
Treatment Sites Identified in Baseline Road Inventory							
Treatment Priorities	Core area			Non-core area			
	HCP/NCCP Implementation						
	Year 10	Year 20	Year 40	Year 10	Year 20	Year 30	Year 40
High	70%	30%		33%	33%	33%	
Moderate	50%	50%		33%	33%	33%	
Low	25%	25%	50%	25%	25%	25%	25%

Table 8-19 Percentage of Controllable Erosion Treated Per Year in the Plan Area

Controllable Erosion							
Treatment Sites Identified in Baseline Road Inventory							
Treatment Priorities	Core area			Non-core area			
	HCP/NCCP Implementation						
	Years 1- 10	Years 11-20	Years 21-40	Years 1-10	Years 11-20	Years 21-30	Years 31-40
High	7%	3%		3.3%	3.3%	3.3%	
Moderate	5%	5%		3.3%	3.3%	3.3%	
Low	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%

There will be annual fluctuations in the percentage of road sites repaired due simply to operational issues and management decisions. The annual percentages in Table 8-19 represent an average.

8.3.3.2.4 Grants for sediment reduction

Table 8-17 sets forth ESA and NCCPA mitigation requirements for sediment reduction which will occur every year, even if there is no timber harvest. Any road repairs or other sediment reduction work over and above the requirements in Table 8-17 will exceed mitigation requirements and is expected to be eligible for state and federal grant funding. Additional sediment reduction work funded by grants or other means would reduce sediment at an even faster pace than is required by our HCP/NCCP.

8.3.3.2.5 Ongoing road inventories

So far the discussion in this sub-section has addressed the treatment of controllable erosion sites identified through the baseline road inventory. MRC will complete additional road inventories every 10 years, starting at Year 20. The Year-20 road inventory will identify further controllable erosion sites and designate a treatment priority for each one. Starting at Year 30 of HCP/NCCP implementation, MRC will treat, every 10 years, the top 1/3 of these newly-identified sites from a list sorted by treatment priority. This sorted list will exclude those controllable erosion sites previously designated in the baseline road inventory.

8.3.3.2.6 Low priority sites

Treatment will differ in low-priority sites. Many road features, such as culverts or rocked fords, have adequate design but present a risk of sediment delivery if a site is not properly maintained. This is an example of a low priority site. MRC will consider erosion at low-priority sites “controlled” if a site is maintained according to standards. We will treat all low-priority sites, as determined from the initial road inventory, within 40 years of HCP/NCCP implementation (Tables 8-18 and 8-19).

8.3.3.2.7 Road erosion not associated with a treatment site

Roads can contribute sediment to streams through erosion of the road surface itself. While not directly associated with individual sites, such as culverts, this surface erosion can, cumulatively, impair streams especially during heavy rain. MRC will reduce road surface erosion within specific timelines. Within the coho core areas (HCP/NCCP Atlas, MAPS 26A-C), MRC will accelerate the improvement of road networks. During the first 10 years of HCP/NCCP implementation, MRC will upgrade 70% of the road systems in accordance with Appendix E, *Road, Landing, and Skid Trail Standards*. We will upgrade the remainder of the roads by Year 20 of HCP/NCCP implementation. Again, this schedule ensures that MRC will upgrade all roads within coho core area within 20 years of HCP/NCCP implementation, and all roads in non-core areas within 30 years of HCP/NCCP implementation.

8.3.3.2.8 Impact of harvest rate on erosion treatment

Finally, road repairs will generally be commensurate with harvest operations. Regardless of harvest rate, however, MRC will treat all controllable erosion identified in our baseline road inventory within the first 40 years of HCP/NCCP implementation. Between 1998 and 2007, MRC controlled approximately 737,000 yd^3 of sediment or roughly 73,000 yd^3 per year.

8.3.3.2.9 Road construction and decommissioning

Approximately 10% of the plan area is AMZ. As of 2009, there are 294.6 miles of active roads, i.e., permanent, seasonal, or temporary roads, within the AMZs of Class I, Large Class II, and Small Class II streams (see Table 3-14). In addition, as of the same date, there were 73.92 miles of decommissioned or historic roads,[27] within Class I, Class II, and Class III AMZ (see Table 3-14). The far right columns of Table 8-20 also include the number of decommissioned watercourse crossings and culverts throughout the entire plan area. Particularly in AMZs, MRC intends to limit new road construction, where possible, and promote road decommissioning across our land. Table 8-21 provides estimates for road work within 10 years of HCP/NCCP implementation.

Table 8-20 Decommissioned Roads, Crossings, and Culverts

HCP/NCCP Plan Area (2009)									
Decommissioned and Historic Roads within AMZs					Entire Plan Area				
					Decommissioned Crossings or Culverts				
Watershed	Total Miles	Class I AMZ (miles)	Large Class II AMZ (miles)	Small Class II AMZ (miles)	Total	Class I	Large Class II	Small Class II	Class III
Albion River	1.08	.33	.50	.25	22	3	2	6	11
Alder/Schooner	2.98	2.32	.43	.24	0	0	0	0	0
Big River	5.41	1.73	2.07	1.61	67	5	8	11	43
Cottaneva Creek	.00	.00	.00	.00	3	2	0	0	1
Elk Creek	4.58	4.16	.17	.25	31	14	6	7	4

[27] In defining a historic road we say that it "will not be opened, rehabilitated, or used, based on a review of the sediment delivery consequences and feasibility of repair." In other words, it is more likely that a historic road would deliver more sediment if we tried to "fix" it than if we left it alone. Consequently, we let nature, undisturbed, take its course and obliterate the road over time. Where it is called for, decommissioning is a more active, expensive, and immediate process. It involves removing culverts, stream crossings, and ditches. In some cases, roads are re-contoured and slopes re-shaped to reflect their natural grade before any cut-and-fill took place. Where the ground was disturbed or excavated, fill, compaction, and stabilization may be required. Finally, re-vegetation puts the road to rest.

HCP/NCCP Plan Area (2009)									
Decommissioned and Historic Roads within AMZs					Entire Plan Area				
					Decommissioned Crossings or Culverts				
Watershed	**Total Miles**	**Class I AMZ (miles)**	**Large Class II AMZ (miles)**	**Small Class II AMZ (miles)**	**Total**	**Class I**	**Large Class II**	**Small Class II**	**Class III**
Garcia River	1.47	.79	.36	.32	47	10	4	15	18
Greenwood Creek	5.53	4.38	1.00	.14	30	9	3	3	15
Hollow Tree Creek	26.07	19.46	3.63	2.97	325	102	45	64	114
Navarro River	18.45	11.87	4.14	2.45	103	35	16	25	27
Noyo River	8.35	6.23	1.24	.88	35	13	7	5	10
Upper Russian R.	.00	.00	.00	.00	7	5	0	0	2
Total	**73.92**	**51.27**	**13.54**	**9.11**	**670**	**198**	**91**	**136**	**245**

Table 8-21 Estimated Road Work within 10 Years of HCP/NCCP Implementation

Plan Area					
Watershed Analysis Units	**Decommissioned Roads (miles)**	**New Road Construction (miles)**	**% of Roads on Slopes > 50%**	***New Road Construction in Class I or Large II AMZ (miles)**	****Future Construction of Class I or Large Class II Crossings**
Albion River	0	0	0%	0	0
Big River	8.0	17.0	50%	0.5	10 Large II
Garcia River	0	2.0	50%	0	0
Navarro River	23.0	20.0	50%	1.0	5 Large II
Hollow Tree Creek (SF Eel)	7.3	7.3	50%	0	0
Noyo River	5.0	15.0	50%	0.5	10 Large II
Cottaneva, Howard, Hardy, and Juan Creeks	0	0	50%	0	0
Alder, Elk, Greenwood, and Mallo Pass Creeks	0	0.4	0%	0	0
Russian River	2.0	3.5	50%	1.0	2 Large II 1 Class I

TABLE NOTES
* Does not include crossings
** Does not include replacements

8.3.3.2.10 Increase the proportion of temporary roads

During wet weather, roads with heavy traffic produce substantially more sediment than do abandoned or low-use roads (Reid and Dunne, 1984). The majority of MRC roads are seasonal—often with permanent structures, such as culverts, which require maintenance and pose risks for sediment delivery. The removal of high-maintenance culverts from low use-roads, followed by installation of low-maintenance crossings, will decrease the risk of sediment delivery across the plan area.

Table 8-22 shows the percentage and mileage of MRC roads by class (permanent, seasonal, temporary) within the plan area as of 2009. MRC will shift to a road system in which more than half the roads are *temporary*. This will lower road maintenance. It will also reduce sediment delivery because there will be fewer culverts or high maintenance stream crossings that could fail. In addition, less road usage in the winter will lead to less erosion from traffic. All of this activity will coincide with the initial phase of our harvests throughout the plan area.

Table 8-22 Percentage and Mileage of Roads by Class within the Plan Area

Plan Area (2009)							
Watershed Analysis Unit	**Permanent Roads**		**Seasonal Roads**		**Temporary Roads**		**Total Miles (rounded)**
	%	**Miles**	**%**	**Miles**	**%**	**Miles**	
Albion River	23.4	37.4	37.7	60.3	38.8	62.2	160
Alder Creek/Schooner Gulch	21.5	9.6	75.3	33.8	3.1	1.4	45
Big River	12.8	45.8	56.8	203.6	30.3	108.5	358
Cottaneva Creek	6.3	6.8	47.0	50.8	46.6	50.4	108
Elk Creek	3.9	4.7	47.6	57.6	48.4	58.6	121
Garcia River	7.5	9.5	62.7	79.9	29.7	37.9	127
Greenwood Creek	2.3	2.1	65.8	58.5	31.7	28.2	89
Hollow Tree Creek	10.7	15.0	36.6	51.1	52.6	73.5	140
Navarro River	6.0	36.4	61.5	372.5	32.4	196.7	606
Noyo River	2.1	4.3	84.6	173.0	13.2	27.0	204
Rockport Coastal Streams	13.8	15.9	48.5	55.9	37.5	43.2	115
Upper Russian River	18.3	8.0	45.5	19.8	36.0	15.7	44

8.3.3.2.11 Skid trail system plan

During preparation of a PTHP, MRC will inventory skid trails to pinpoint the controllable erosion sites. We propose within the first 5 years of our HCP/NCCP to also complete a baseline inventory of skid trails. The baseline inventory will use aerial photographs combined with limited field visits for sampling verification. In a trial survey done in the Garcia, MRC mapped skid trails crossing watercourses or skid trails adjacent to watercourses; the survey was completed from aerial photographs for a variety of locations, including several hillslope morphologies (swales, planar slopes, open canyons, incised canyons) and varying watersheds. MRC did not find controllable erosion sites from skid trails in swales, planar slopes, and open canyons. However, we frequently found such sites where skid trials were directly adjacent to or crossed incised canyons. Mapping and field sampling will allow MRC to (a) gauge overall controllable sediment from the skid trail network on our land and (b) guide foresters to areas of high sediment production for planning analysis.

When MRC identifies with aerial photographs skid trails likely to produce controllable erosion, we map the site for later verification. A forester will visit the site during PTHP preparation. This field visit substantiates whether the site is indeed a controllable erosion site. If it is, MRC will then determine the volume of controllable erosion. Once the inventory from the baseline aerial photo is complete, MRC will assign the site a priority and schedule the repair using prioritization categories (see section 8.3.3.2.1). We will treat most of the controllable erosion during the first timber harvest operation in the area. Treatment will depend on whether equipment or personnel can perform erosion control without creating more sediment than the site would produce if left untreated.

In the State of California, operations that affect the bed or banks of a lake or stream require approval from CDFG through an alteration agreement, also called a 1600 permit (see Appendix T, *Master Agreement for Timber Operations*). CDFG must also approve maintenance to a skid trail if it involves the banks or beds of a stream. This oversight from CDFG will continue even when our HCP/NCCP is in place. MRC estimates that we will treat historic sources of skid trail sediment, when feasible, within the first 30 years of our HCP/NCCP.

8.3.3.2.12 Reducing sediment from point source erosion and surface erosion

MRC will reduce sediment from point source erosion (i.e., wash-outs and gullies at watercourse crossings) and surface erosion off roads in several ways: (1) through upgrades to controllable erosion sites; (2) through appropriate surfacing of roads in close proximity to watercourses; (3) through limitation of road use during the winter period; and (4) through reducing permanent watercourse crossings.

Treatment of controllable erosion sites and upgrades of road design standards will reduce sediment from roads. Some have estimated that such treatment and upgrades reduce sediment from roads by 90% (NCRWQCB 1998). Treatment of sites initially identified with high and moderate erosion and upgrade of a majority of the road design standards will occur in the first 30 years of our HCP/NCCP. However, it is likely that new erosion sites will develop and treatment will occur over the entire 80-year term of the plan. MRC will further minimize controllable erosion by reducing the number of permanent watercourse crossings. Still, a 90% reduction of sediment inputs from point source erosion at any one time is unlikely. MRC estimates, however, that a 75% reduction is possible.

MRC can control surface erosion from logging roads by limiting road use during wet periods and providing road cover to bind or armor the road surface (i.e., vegetation, rock, or pavement). Based on data from our road inventory, 80% of MRC roads are native surface (compacted soil) and 20% have a rock or paved surface. According to the surface erosion model in the Standard Methods for Conducting Watershed Analysis, Version 4.0, Washington Forest Practices Board (WFPB), application of at least 6 in. of rock to a road surface reduces sediment production by 80%. Furthermore, according to the same model, roads with moderate to high traffic can have sediment inputs reduced by at least 50% when road use is limited in wet periods.

Our road design standards require that road surfaces be rocked, paved, or suitably covered (slash, grass, mulch, etc.) within the AMZ, depending on watercourse and road type. Use of roads during wet periods is restricted as well. We assume that applying 6 in. of rock or other material to road surfaces (as in the WFPB model) will reduce sediment production by 80%. We further assume that watercourse crossings with native surfaces are proportionate to the amount of roads with native surfaces (80% in 2002). Sediment delivery also comes from road cut-and-fill portions of the prism that cannot have armoring (rock, pavement) applied. Also surface erosion from outside the AMZ, where road surface treatments may not be required, can deliver sediments. However, it is not likely that these sources will produce large amounts of erosion. We assume that limiting road use in wet periods will make up for surface erosion from outside the AMZ and from the cut-and-fill portions of the road prism.

The spacing of waterbreaks—such as waterbars, rolling dips, and ditch relief culverts—can affect erosion rates of road surfaces. Raindrops are very effective in detaching soil particles (Chang 2003). The impact energy of raindrops is the major initiator of soil detachment (Young and Wiersma 1973). Sediment yield is the net result of (a) sediment detachment by raindrops and flowing water; (b) sediment transportation by raindrop splash and flowing water; and (c) sediment deposition (Lane et al 1995). The product of sediment concentration (mass per unit volume of water) and flow rate (volume of water per unit time) gives the sediment discharge rate in mass per unit time. By integrating sediment discharge rates throughout the period of flow, sediment yield is obtained from the contributing area above the point of interest (Lane et al 1995). In summary, the goal is to reduce surface erosion on roads; minimizing the distance between waterbreaks reduces the contributing area on road surfaces.

MRC analyzed data on logging roads from the Navarro River and Noyo River watersheds. We compared sediment inputs from point source erosion with total sediment inputs from surface erosion and point source erosion combined. According to the analysis, point source erosion amounted to 22-71% of the total sediment inputs, with a median value of 52%. Using this median value, with point source erosion lowered by 75% and surface erosion lowered by 65%, overall road point source and surface erosion sediments is estimated to be lowered by 70%. Over time, roads will deteriorate and require constant maintenance and upgrade; this ongoing maintenance and upgrade will further improve MRC roads and reduce sediment inputs.

MRC **estimates** that

1. At least 50% of sediment inputs from point source and surface erosion will be reduced within the first 30 years of our HCP/NCCP.
2. At least 70% of sediment inputs from point source and surface erosion will be reduced by the end of the 80-year term of our HCP/NCCP.

8.3.3.3 Instream sediment

MRC is not proposing specific conservation measures for instream sediment. However, we will reduce stream inputs through our conservation measures for mass wasting and our road standards, all outlined in sections 8.3.3.1 and 8.3.3.2.

8.3.4 Rationale

8.3.4.1 Greatest protection for greatest risk of sediment delivery

Delineation of the landscape into TSUs is fundamental to the success of the mass wasting conservation measures; therefore, during watershed analysis geologists consider several factors:

- Landslide characteristics
  - Size.
  - Frequency.
  - Delivery to watercourses.
  - Spatial distribution.
- Hill slope characteristics
  - Slope form (convergence, divergence, planar).
  - Slope gradient.
  - Contributing area.
  - Magnitude of stream incision.
  - Overall geomorphology.

The geologist uses these factors to make a “best professional judgment” as to the proper location of the TSU boundary.

The MRC strategy for mitigating anthropogenic mass wasting emphasizes high protection near watercourses where mass wasting hazard is high and subsequent risk of sediment delivery is high. Examples of high protection would be inner gorge and steep streamside slopes of TSU1 and TSU2. MRC also focuses on protections for steep, dissected terrain where mass wasting hazard is moderate-to-high and subsequent risk of sediment delivery is moderate-to-high. This would apply to TSU3. MRC analysis of sediment delivery in select watersheds is consistent with findings from other landscapes which show that a great majority of sediment delivery comes from these areas (Table 8-23).

Table 8-23 Percent Mass Wasting Sediment by High Hazard TSU

Watershed Analysis Unit	Inner Gorge or Steep Streamside Slopes (TSU1 and TSU2)	Steep, Dissected Topography (TSU3)	Total Sediment Delivery from High Hazard TSU (TSU1-TSU3)
Albion WAU	15%	29%	44%
Big River WAU	53%	22%	75%
Noyo WAU	40%	51%	91%
Navarro WAU	31%	51%	82%
Garcia WAU	76%	8%	84%
Greenwood WAU	47%	9%	56%

Table 8-23 suggests that by mitigating mass wasting concerns on TSU1, TSU2, and TSU3, MRC will reduce most of the management-created sediment delivered from landslides. Accomplishing this will require training foresters to recognize hazard areas in the field.

Research conducted in similar terrain reveals there are two unstable areas of a hillslope that are most likely to fail: headwall swales (a.k.a. bedrock hollows or zero-order swales) and inner gorges (Benda et al. 1998). Our mass wasting strategy addresses these areas in the conservation measures for TSU1 and TSU2 (inner gorges and steep streamside slopes), and TSU3 (headwall swales or locally steep slopes). If we assume homogenous bedrock and soil conditions (which is certainly not the case in Franciscan geology), there are two parameters with a significant influence on slope stability: slope gradient and shape (Sidle et al. 1985, Dietrich et al. 1998, Benda et al. 1998). In general, shallow mass movements increase as hillslope gradient increases (Sidle et al. 1985). Preliminary results from our mass wasting inventories for watershed analysis indicate that most shallow mass movements occur on slopes >65%. Slope shape also has an influence on shallow mass failures. Concave slopes tend to accumulate soil (colluvium) to greater depths and build up pore water pressures which can contribute to slope failure (Dietrich et al. 1998). The discharge rate of accumulated subsurface water from unstable soils is probably the most important hydrologic function affecting slope stability (Sidle et al. 1985). Repeated failures in and around old landslide initiation sites are common in steep terrain with relatively shallow soils (Sidle et al. 1985). Our mass wasting approach relies heavily on our foresters to decide, based on indicators of potential and past slope failure, whether the assessment of a professional geologist is necessary.

8.3.4.2 Canopy retention for mass wasting concerns

Many of the default conservation measures for mass wasting rely on canopy retention to maintain hydrologic functions and root strength on areas with mass wasting hazard.

INTENT	The intent of canopy retention is to provide forest stands with canopy for precipitation interception, evapotranspiration, and root structure in the soil mantle. Additionally, when slope failures do occur, canopy retention will ensure that LWD is delivered to the stream channel.

Canopy retention intercepts precipitation and facilitates subsequent evaporation of incoming precipitation. In addition, tree canopy is a surrogate for root strength; through canopy retention, vegetation retains root strength.

The effect of clearcut harvesting and subsequent increases in mass wasting and sediment inputs has been documented (i.e. Bishop and Stevens 1964, Gray 1970, O'Loughlin 1974, Montgomery et al. 2000). Still, there is little documentation on the effects of partial harvest on mass wasting and sediment delivery.

Generally, timber harvest reduces soil cohesion through root degradation and increases soil moisture by reducing the amount of rainfall interception and evapotranspiration. This, in turn, impacts slope stability.

8.3.4.3 Reduced root strength

The gradual decay of root systems in non-sprouting tree species can predispose provisionally stable slopes to failure (Gray and Megahan 1981, Ziemer 1981b, O'Loughlin and Ziemer 1982). Root systems contribute to the strength of the soil by providing a component of effective cohesion (Sidle et al. 1985). Increased landslide rates, occurring about 3-10 years after clearcutting, have been attributed to loss of root strength (Megahan et al. 1978). This period of increased landslides corresponds to the minimum rooting strength of the site following initial root decay and prior to substantial regeneration of trees (Sidle 1992). In fact, it may take as many as 25 years for a regenerating clearcut to restore over 50% of its original root strength (Ziemer 1981b). The positive effect of root strength is most pronounced in shallow cohesionless soils on steep slopes (Chatwin et al. 1994). In cohesive soils, the positive effect of root systems is less pronounced; additionally, where sprouting species are harvested and the root network does not decay, the negative effect of the harvest would be significantly less.

The effect of root decay on slope failures seems to be more pronounced in regions where there is harvesting of non-sprouting species. In the redwood region, where sprouting species such as coastal redwood and tanoak maintain a viable root mass even when cut, loss in root strength should be much less pronounced. In Caspar Creek, which is located in the redwood region, Cafferata and Spittler (1998) found little difference between landslide-associated sediment delivery in clearcut versus uncut stands; this was despite rainfall of high intensity and long duration that could potentially trigger a slope failure. Preliminary findings from a mass wasting inventory conducted on JDSF reveals no observed increase in the rate of shallow landsliding from timber harvest in clearcut units (Bawcom 2003, as cited in Keppeler et al. 2003). However, not all root masses of these species survive; among those that do, there will be a period during which the effective roots diminish (Ziemer and Lewis 1984). A USDA Forest Service report documents the decline and recovery of root biomass in redwood and mixed conifer forests of northwestern California (Ziemer and Lewis 1984).

8.3.4.4 Increased soil moisture

The hydrologic consequences of vegetation removal are less well known. Without rainfall interception, increased levels of precipitation infiltrate the ground surface; this increases pore water pressure and perhaps the potential for triggering a mass wasting event. In a 100-year-old second growth stand of redwood and Douglas fir in Caspar Creek, measurements of rainfall, through-fall, and stem-flow indicate that approximately 22% of rainfall is lost to storage or evaporation before it reaches the ground (Reid and Lewis 2004).

While increased amounts of rainfall after timber harvest may or may not initiate slope failure, soil will drain accumulated sub-surface water for a longer period after rainfall; this may leave the slope more susceptible to failure when it receives additional sub-surface water in the next rainfall. It is well known that shallow slope failures typically occur during peak groundwater conditions (near saturation) in response to intense rainfall (Sidle et al. 1985). Therefore, the likelihood that a slope will fail may be more influenced by the recurrence interval of high intensity, long duration, rainfall, rather than vegetation removal; such removal only incrementally increases the amount of water reaching the soil mantle during each rainfall. Vegetation removal, however, would certainly have a worse effect on slopes approaching failure prior to rainfall.

Thomas Spittler, Senior Engineering Geologist with CGS, has noted that in at least one example in northern California—Bear Creek, Humboldt County—harvesting most (i.e., >50%) of the watershed significantly increased landslides in inner gorge.[28] The observations at Bear Creek, which followed high intensity rainfall in January 1997, suggest that where inner gorges are present and where a regeneration harvest of even-aged stands was applied to 50% or more of the slope above the inner gorge, landslides and sediment delivery were common. When an inner gorge was not present or little canopy was removed, landslides were uncommon. According to a California Department of Conservation (1998) memorandum, debris slides are more common in sub-watersheds where 50% or more of the slopes are harvested.

The observations in Bear Creek support the hypothesis that reduction of upslope vegetation increases soil water levels down slope. During rainfall of high intensity and long duration, this also increases the number of landslides. Observations by other hydrologists support the hypothesis. For example, Keppeler and Ziemer (1990) found increases in water yield in a watershed with 67% of the timber volume harvested. Hibbert (1967) suggested that increases in stream flow increased proportionately to the amount of cover removed. Similarly, Rothacher (1971) suggested that forest harvest increased baseflow.

Removing vegetation in a watershed does increase baseflow, and one might conclude that this would increase mass wasting. However, Rothacher (1971) pointed out that partial cutting is less effective than clearcutting at increasing baseflow. Some observations have suggested that partial cutting may actually deplete soil water due to increased evapotranspiration by understory vegetation; it may also promote forest regeneration with increased energy and water for the understory (Greenwood et al. 1985).

Our mass wasting conservation measures propose standards for canopy retention to use evaporation and transpiration of soil moisture. Trees also provide root structure in the soil mantle. This increases the cohesive properties of the soil and creates flow paths along root macro-pores that facilitate soil water infiltration and hillslope drainage. If mass wasting does occur, large wood and woody debris from the canopy and other trees will retain a certain amount of the resulting sediment. The fact that failed slopes may deliver large wood to streams could mitigate impacts on stream habitat or even enhance stream habitat. For this reason, the conservation measures for TSU1 through TSU3 retain, per acre, at least 15 ft^2 of conifers with a dbh $\geq$18 in.

We acknowledge the inherent uncertainty in estimating the precise level of canopy retention needed to relieve mass wasting concerns. However, based on (1) a review of the literature, (2) findings from landslide studies in the redwood region, (3) the conservation measure for no harvest on inner gorge slopes and historically active areas, and (4) the proposed AMZ protections, the MRC proposal to retain 50% of the canopy on potentially hazardous ground appears adequate to minimize the impact of harvest-related landslides. Furthermore, MRC will retain 50% canopy on average across each watershed (excluding pygmy forest, natural grassland, oak woodland, and natural brush areas).[29] Use of uneven-aged management techniques over time will lead to increased canopy closure on both the harvest scale and the watershed scale.

8.3.4.5 5% alternative

To meet our long term objectives, MRC will use a limited amount of regeneration harvest management. As we have already said, those objectives include the reduction of hardwood in areas where hardwood is a significant component and the transition of MRC forest toward uneven-aged management. These regeneration harvests will primarily occur during the first 30 years of our HCP/NCCP. They may occasionally go below the default prescriptions for areas of mass wasting hazard.

[28] Email from Tom Spittler (CGS) to Kirk Vodopals (MRC) on August 10, 2006

[29] This is a simple example of canopy calculation across a watershed: (1) ½ of a watershed has partial harvest leaving 50% canopy; (2) ½ of the same watershed has 100% canopy; (3) the average canopy across the watershed is 75%, i.e., (0.5*50% + 0.5*100% = 75%).

MRC will limit regeneration harvests to 5% of the area of all the high hazard terrain units within a CalWater planning watershed over a 10-year period. Additionally, within a PTHP, we will only allow 5 ac of such harvests to occur for each high hazard terrain unit (i.e., TSU1 through TSU3).

Table 8-24 provides an example from a planning watershed where MRC controls most of the basin. MRC owns approximately 90% of the Little North Fork Navarro planning watershed which is tributary to the North Fork Navarro. Since the area where regeneration harvests will occur is based on a percentage of the high hazard ground, the level of impact ties directly to the total amount of the plan area in the planning watershed and the total amount of high hazard ground on that land.

Table 8-24 Example of the 5% Alternative

Little North Fork Navarro	
Area	Acres
Total Planning Watershed	7085
MRC Timberland	6423
TSU1, 2, 3	1857
5% of TSU1, 2, 3	**93**

In the above example, MRC could reduce forest canopy below the default harvest limit (i.e., 50% canopy cover) in 93 ac of the Little North Fork Navarro during a 10-year period. However, we could not harvest more than 5 ac per TSU in any given PTHP. Therefore, the default canopy of TSU1 could only be reduced 5 ac. The same would apply to TSU2 and TSU3. Essentially, this means that a maximum of 15 ac per PTHP could be reduced below the default conservation measures without a geologic or biologic assessment. Sticking with this example of the Little North Fork Navarro, MRC could propose 6 PTHPs, all with the maximum 15-acre alternative, to reduce canopy below the 50% default within a 10-year period (6 * 15 ac = 90 ac of regeneration harvest).

The intent of the *5% alternative* is to provide some flexibility where default conservation measures would normally not allow it, without significantly increasing sediment yield from mass wasting. MRC believes the *5% alternative* is reasonable based on estimates of sediment delivery from mass wasting in select watershed analysis units. There will be no alternative to the default conservation measures for timber harvesting on historically active areas or inner gorge slopes; conservation measures describe the geologic and biologic assessment for these areas. Table 8-25 gives an estimate of the potential impact from the *5% alternative* in the individual watershed analysis units.

Table 8-25 Estimated Sediment Delivery From 5% Alternative

Estimated Sediment Delivery From 5% Alternative					
WAU	**Total MRC Acres in TSU 1 to 3**	**Area of WAU in TSU1-3 (% of acres owned)**	**Acres of Canopy Reduction below 50% by WAU per Year***	**Sediment Delivery Rate from Non-Road Related Landslides (tons/mi^2/yr)**	**Estimated Sediment Delivery from 5% Alternative (tons/mi^2/yr)**
Noyo	5495	60%	58	371	19
Navarro	14,553	27%	74	218	11
N. Russian	550	47%	13	65	3
Albion	2290	15%	12	161	8
Greenwood	1830	18%	9	111	6

Estimated Sediment Delivery From 5% Alternative					
WAU	**Total MRC Acres in TSU 1 to 3**	**Area of WAU in TSU1-3 (% of acres owned)**	**Acres of Canopy Reduction below 50% by WAU per Year***	**Sediment Delivery Rate from Non-Road Related Landslides (tons/mi^2/yr)**	**Estimated Sediment Delivery from 5% Alternative (tons/mi^2/yr)**
Garcia	2642	21%	12	602	30
Big River	8004	23%	39	172	9

TABLE NOTE
* If MRC harvests the maximum 5% per decade

To arrive at the numbers in the last column of Table 8-25, MRC multiplied the sediment delivery rates from non-road-related landslides within each WAU by 5% and rounded up. For example, in the Noyo WAU, 371*.05=18.55≈19 tons/mi^2/yr. The assumption is that rates of non-road-related landslides from watershed analysis, analyzed for the past 20-30 years, simulate future canopy reduction below 50%. The rationale for this assumption is that a common silvicultural technique from the 1970s through the 1980s was the use of shelterwood removal, where a majority of overstory canopy was removed. Previous landowners used this practice extensively in the plan area.

Prior to the 1993 Forest Practice Rules related to silviculture, use of shelterwood removal did not follow current industry standards. A typical shelterwood removal would harvest large shelter trees and leave only a well-established forest of mainly younger conifers. In the 1980s, shelterwood removal allowed for the harvest of an unlimited number of trees per acre, even in old-growth forest. Only a minimum amount of stocking was left behind. Changes to the Forest Practice Rules in 1993 reigned in the use of this method of even-aged management to more acceptable acreage restrictions and post-harvest stocking levels. As well, during the 1993 Forest Practice Rule revisions, "late seral" stands of 20 ac or more had to be described in the THP and were offered more protection than previously. Today, in typical post-harvest stands where MRC has applied seed tree removal, stands have an uneven-aged appearance and characteristic to them.

The analysis also assumes that a majority of non-road-related sediment is generated from TSU1, TSU2, and TSU3. Additionally, we assumed that our estimates are minimum amounts of sediment delivery, as explained in Appendix G, *Watershed Analysis: Background and Methods*. Although field reconnaissance plays a significant role in determining sediment delivery rates, we do not conduct ground surveys over an entire WAU; as a result, estimates are considered minimums. While estimates are minimums, the delivery rates are from landslides where past harvesting occurred not only on inner gorge slopes, but also on historically active areas. The proposed conservation measures for mass wasting are more restrictive on streamside harvesting; they do not allow timber harvesting on inner gorge slopes or historically active areas unless an assessment is conducted by a geologist and a biologist. An assessment evaluates the impacts of proposed operations and draws conclusions based on site conditions. In light of this, the proposed *5% alternative* is not likely to result in a significant increase in sediment delivery from landslides related to timber harvest.

8.3.4.6 Estimates of sediment reduction

Estimates from select watershed analysis units suggest that approximately 60% of sediment inputs in the last 30-40 years have been from mass wasting. Of these inputs, 57% are from mass wasting associated with roads and 43% from other sources. Some portion, though difficult to determine, of non-road-related mass wasting occurs naturally. MRC believes the conservation measures proposed in this plan will reduce sediment delivery from mass wasting caused by management practices.

Road construction on any hillslope will inevitably decrease the stability of the site by adding weight to the fill slope; steepening the cut-slope and potentially the fill-slope; removing buttressing support of the cut-slope; and concentrating and rerouting drainage water (Sidle et al. 1985). For road-related mass wasting, our protection measures focus on avoiding road layouts on mass wasting hazards; improving drainage and design on the existing road system; and improving the design of future road prisms to minimize the impact of a road on the stability of a slope. The road prism consists of the road surface, as well as other features such as cutslope, fillslope, ditches, and storm drainage (Figure 8-17). There is considerable study and literature on the effects of logging roads on mass wasting, but little literature on the effects of improved road design in reducing mass wasting hazards.

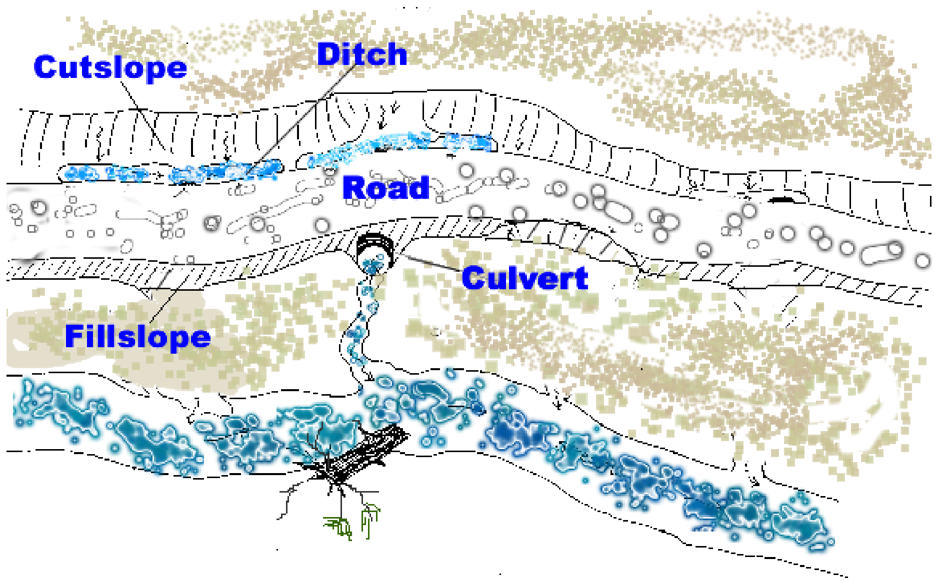


Figure 8-17 Road Prism

Sidle et al. (1985) presents a comprehensive review of comparative rates of soil mass movements from road-related disturbance versus undisturbed land. Results from the many studies show a 30-300 fold increase in the erosion rate dues to road-related mass wasting (Swanson and Dyrness 1975, Morrison 1975, Marion 1981, Ketcheson and Froehlich 1978, Swanson et al. 1977, Fiksdal 1974, O'Loughlin 1972, Gray and Megahan 1981, O'Loughlin and Pearce 1976). Much of the research has been conducted in the Oregon Coast Range and Oregon and Washington Cascades, where geomorphic conditions are not unlike those in the plan area.

This research is consistent with studies in the redwood region where a majority of sediment delivery from mass wasting is attributed to roads. In Caspar Creek, Cafferata and Spittler (1998) noted that almost all of the recent landslides delivering sediment to South Fork Caspar Creek were associated with roads and skid trails constructed prior to implementation of the California Forest Practice Rules. Prior to implementation of the Forest Practice Rules, many miles of road were constructed on steep unstable slopes using sidecast construction methods, with stumps and logs buried on the outside of the road prism. These methods resulted in thick un-compacted fills on steep slopes—in many cases directly adjacent to a watercourse. Field reviews conducted during watershed analysis confirm that a majority of road-related failures in the plan area originate from thick sidecast fills on steep slopes. A concise summary of forest road-related mass wasting by NCASI (2001) reveals these findings are consistent with other studies; these studies show that road-related landslides that prove most damaging to streams occur primarily from fill and sidecast failures on slopes >70%, and secondarily from culvert and stream crossing failures (Bush et al. 1997, Fiksdal 1974, Gonsior and Gardner 1971, Gray and Megahan 1981, Megahan et al. 1978, McClelland et al. 1997, Sidle et al. 1985, Skaugset et al. 1996, Swanson and Dyrness 1975, Jones et al. 2000).

Sessions et al. (1987) found that sidecast construction and moderate road grades in stable soil types in western Oregon resulted in 40 times more slides per mile of road then full bench roads on steeper grades. The difference in less stable sandy or gravelly soils was only a factor of 2 (NCASI 2001). This shows the importance of underlying geology and soils as a controlling factor in road-related mass wasting. While sidecast road construction on steep slopes is a significant contributor to mass wasting, the effects of construction method are overwhelmed by the effects of underlying geology if unstable bedrock or soil conditions are traversed. Conservation measures proposed in our HCP/NCCP prohibit road building across historically active slide areas unless a geologic and biologic assessment of site conditions is conducted.

Despite the inherent uncertainty about improved road design and its effect on sediment delivery, MRC believes road-related mass wasting can be significantly reduced as old roads on steep slopes are upgraded and new road layouts are carefully planned prior to construction. Therefore, we make the assumption that improved road design and avoidance of historically active slide areas can reduce sediment delivery from road-related mass wasting by 60%.

8.3.4.7 Mass wasting related to timber harvest

The influence of a particular timber harvest on slope stability depends on the density of residual trees and understory vegetation; rate and type of regeneration; site-specific physical characteristics; and patterns of water inflow (storms) after harvesting (Sidle et al. 1985). Our primary protection against mass wasting from timber harvest is canopy retention to provide root strength, interception of precipitation, and transpiration of soil moisture.

While attributing mass wasting to roads is typically a trivial task, attributing mass wasting to timber harvest can be quite problematic. Past research on the subject of timber harvest has focused on undisturbed forest and clearcuts (e.g., Swanson and Dyrness 1975, Morrison 1975, Marion 1981, Ketcheson and Froehlich 1978, Swanson et al. 1977, Fiksdal 1974, O’Loughlin 1972, Gray and Megahan, 1981, O’Loughlin and Pearce 1976). After clearcutting, all inventoried landslides are typically attributed to timber harvest. This may take the subjectivity out of interpretation, but it likely overestimates the actual rate of mass wasting as a result of timber harvests; clearly, it doesn’t account for natural landslides occurring in harvested units. Additionally, aerial photo analysis, which is the typical inventory method for landslides, is not foolproof at detecting them, particularly small landslides, under dense forest canopy. As a result, observers can underestimate the rate of landslides in undisturbed forest conditions (Robison et al. 1999).

Robison et al. (1999) reported that sediment volumes from landslides were greater in stands 0-9 years old (i.e., recently clearcut), than stands over 100 years old. However, the greatest volume of sediment from landslides was in a stand that had not been harvested in 100 years. This example illustrates the variability in sediment delivery from mass wasting in mountainous forested terrain, especially in the Pacific Northwest where earthquakes and rainfall of high intensity and long duration are relatively common.

Numerous landslide studies summarized by Sidle et al. (1985) reveal an increase in the rate of mass wasting after clearcuts, namely, 2-40 times that in undisturbed forest, with a median 3.7 fold increase (Swanson and Dyrness 1975, Morrison 1975, Marion 1981, Ketcheson and Froehlich 1978, Swanson et al. 1977, Fiksdal 1974, O’Loughlin 1972, Gray and Megahan 1981, O’Loughlin and Pearce 1976). These studies find that the increase in landslide rates after clearcutting is significantly less than the increase after road construction.

Landslide studies conducted in the redwood region on Jackson Demonstration State Forest (JDSF) show no significant increase in the rate of landslides from clearcutting (Cafferata and Spittler 1998). Recent research conducted on JDSF looked at 50 clearcut units (1800 ac) in Hare Creek, Caspar Creek, Big River, and South Fork Noyo. Results reveal that 28 of the 32 mapped failures in the clearcut blocks were attributed to roads, not timber harvest (Bawcom 2003, as cited in Keppeler et al. 2003).

Because of the complexity in identifying mass wasting related to timber harvest, most researchers simplify the process by only comparing undisturbed forest and clearcuts. Very little research is currently available on how partial harvest affects slope stability. One model found that a 75% partial harvest reduced the probability of slope failure 5 times compared to clearcuts (Sidle 1992). However, the probability of failure was largely influenced by root decay, which is probably not as prevalent in the redwood region where harvested redwoods sprout vigorously from the stump.

Despite the inherent uncertainty in attributing mass wasting to timber harvests, we believe the conservation measures proposed in this plan will reduce sediment delivery from timber harvest. Therefore, we make the assumption that canopy retention on potentially hazardous areas and no harvest defaults on historically active slide areas will reduce sediment delivery from harvest-related mass wasting by 20%.

8.3.4.8 Combined goal

The 60% or more reduction in sediment inputs from road-related mass wasting plus the 20% reduction from harvest-related mass wasting is a final objective of our HCP/NCCP—an objective to be achieved by the end of its 80-year term. At current harvest levels, it will take approximately 30-40 years to upgrade the road network and transition forest management to uneven-aged silviculture. We will not know if our objective is on course until the first 30-40 years of our HCP/NCCP transpire. Nevertheless, based on an up-to-date review of forest research, MRC believes the conservation measures proposed in this plan will ensure our objective is met within the term of our HCP/NCCP.

8.4 Hydrologic change

8.4.1 Goals and objectives

Goal and Objectives for Hydrologic Change	
Goal	
G§8.4.1-1	Limit the adverse impact of hydrologic change on covered anadromous salmonid and amphibian species or on beneficial uses of water.
Objectives	
O§8.4.1-1	Reduce hydrologic change by maintaining at least 50% canopy cover,[30] averaged across CalWater planning watersheds in the plan area.
O§8.4.1-2	Minimize hydrologic connectivity of road systems to watercourses as outlined in Appendix E, *Roads, Landings, and Skid Trails* by upgrading, within the first 30 years of the HCP/NCCP, the MRC road network to these standards.

[30] MRC only measures canopy cover for trees >30 ft in height.

Goal and Objectives for Hydrologic Change	
O§8.4.1-3	Maintain, during water drafting, equivalent temperatures downstream and upstream and limit the reduction of the wetted width of the 1st downstream riffle as well as pool volume.

8.4.2 Conservation measures

MRC is not proposing additional or new conservation measures to address hydrologic change due to forest management. Rather, we will use conservation measures and policies already cited in our HCP/NCCP:

- Uneven-aged management will provide forest canopy to minimize peak and low stream flow changes.
- Increases in LWD recruitment will improve over-wintering habitat for salmonids and make downstream displacement of young-of-the-year from increased peak flows unlikely.
- Implementation of road design standards which minimize concentrated drainage will reduce erosion of channels and banks.
- Adherence to guidelines on water drafting in the Master Agreement for Timber Operations (MATO) will protect covered fish and amphibian species.

8.4.3 Rationale

Forest harvesting influences the stream flow of a watershed through loss of evapotranspiration and interception of precipitation from the forest canopy; increased surface run-off from compacted soil surfaces, such as roads, landings, skid trails, firelines, and cable corridors; and changes in snow accumulation from canopy openings (Harr 1981, Wemple et al. 1996, Ziemer 1998, Lewis et al. 2001). These alterations of the water balance can change size, duration, and frequency of peak flows; low flow discharges; and annual water yield.

The amount and timing of forest harvest and the physical and geographical characteristics of a watershed influence the magnitude of hydrologic change. Hydrologic change due to forest harvest does occur. Do these changes, however, negatively impact aquatic organisms? To target potential damage to aquatic organisms or their habitat, we need to consider the following questions:

- Do increases in peak flow create adverse scour to the streambed and banks?
- Do increases in stream power displace young-of-the-year salmonids or amphibians downstream?
- Can increased peak flow create barriers to upstream anadromous salmonid migration?
- Is there increased potential for transporting LWD?
- Do increases in localized stream flow, due to road drainage, create more sediment from fluvial erosion of a channel or its banks?
- Do changes to low-flow conditions impact aquatic organisms?

8.4.3.1 Peak flow changes due to forest canopy removal

Research at Caspar Creek (Lewis et al. 2001), located adjacent to the plan area in coastal Mendocino County, shows that changes in peak flows can be predicted. The equation to estimate those changes is in Appendix I, *Peak Flow Predictions*. MRC applies this equation to our uneven-aged forest management, assuming it is a reasonable, perhaps conservative, approximation. Jack Lewis, retired statistician with the USDA Forest Service, characterized the peak flow equation in this way:

> For anything but individual tree selection the equation should, for the most part, be a good approximation. In that case, water uptake from live roots of surrounding trees interwoven with the harvested trees, might result in more water use than a harvest of the same volume in a clear-cut. And the recovery period would probably be accelerated as

> formerly competing trees took over. For group selection cuts, water gains should be fairly similar to an equivalent clear-cut. There is one caveat. If the size of the group selection is small enough, then edge effects will become important. For example, roots from border trees will be able to exploit a certain amount of soil water from within the blocks.[31]

In the Caspar Creek research, no relationship was found between increased peak flow and number of roads, skid trails, or other compacted surfaces (Ziemer 1996). However, roads, landings, and skid-trails in North Fork Caspar Creek are all located near ridges and well away from any streams. Further, soil compaction from roads and timber harvest represent only 3.2% of the North Fork watershed and range from 1.9–8.5% for the tributary watersheds. So it is not surprising that roads, soil compaction, and overland flow did not produce changes in peak flow response of the North Fork watershed.

Using our model for landscape planning, MRC estimated canopy retention for 10-year periods. For the canopy predictions, we modeled growth, yield, and harvest in each of the time periods. Canopy retention from individual stands was averaged across the plan area in CalWater planning watersheds; the result represents canopy retained in the plan area. Canopy retention on land not owned by MRC is unknown. Therefore, any estimates of peak-flow increase are for effects created in the plan area.

Peak flow increases were estimated for each decade from 2002-2060 (see Appendix I, *Peak Flow Predictions*). Lewis et al. (2001) state that peak flow increases recovered at a rate of 8% per year after the first harvest. Later research reached a similar conclusion, namely, that such increases return "to pre-harvest flow conditions after about 12 years" (Keppler et al. 2003, 5). MRC actually estimated recovery of peak flow effects at 10 years based on our own silvicultural practices and experience, as well as early conversations between our hydrologist and a mathematical statistician with the Pacific Southwest Research Station, the research and development branch of the USDA Forest Service.[32] Consequently, our analyses for 10-year time periods do not include effects from the previous timeframe.

Our long-term plan is to develop an uneven-aged forest structure where sustainable selective harvest can occur. Uneven-aged forest management ensures that forest canopy is maintained across the landscape. Furthermore, rapid recovery of forest canopy, with canopy returning to pre-harvest conditions, typically occurs within 10 years. Regulated, uneven-aged management will schedule forest harvests in stands approximately every 20 years. Over time the size of trees within the stands will increase, as will the average canopy. We hypothesize that this increase of average canopy, over time, will reduce the intensity of peak flow events in the plan area.

Table 8-26 shows that canopy will increase, as averaged across the plan area within CalWater planning watersheds. Estimated average canopy in 2010 by planning watershed was 65%, with a minimum canopy of 48% and a maximum of 76%. Average canopy increases in 2060 to 73%, with a minimum canopy of 61% and a maximum of 80%. As canopy increases, the cumulative effect of forest harvest on increases in peak flows decreases in the planning watersheds.

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[31] Jack Lewis clarified an earlier statement of his in an email to Kirk Vodopals (MRC) sent on 03/08/2011.

[32] Located in Arcata, CA, Redwood Sciences Lab (RSL) is a field facility of the Pacific Southwest Research Station. Jack Lewis, a mathematical statistician at RSL, discussed this issue in a telephone conversation with Chris Surfleet, the MRC hydrologist at the time, on June 10, 2002. Chris left MRC in 2004 to pursue graduate work at Oregon State University, while Jack retired from RSL in 2008.

Table 8-26 Canopy Closure and Estimated Percent Increase of the Peak Flow[33]

Canopy Closure and Estimated Percent Increase of the Peak Flow															
Inventory Block	**CalWater Planning Watershed**	**Average Percent Canopy Closure by Time Period**							**Percent Increase in Peak flow 2 Year Return Interval**						
		2002	2010	2020	2030	2040	2050	2060	2002	2010	2020	2030	2040	2050	2060
Albion River	Lower Albion River	72	76	76	75	78	78	80	7.1	6.1	6.1	6.1	5.4	5.4	5.1
	Middle Albion River	60	62	61	62	62	67	69	10.0	9.4	10.0	9.7	9.7	8.1	7.6
	South Fork Albion River	63	64	69	71	73	72	76	9.2	9.2	7.6	7.4	6.6	6.9	6.1
	Upper Albion River	66	66	61	60	64	70	75	8.7	8.4	10.0	10.0	9.2	7.4	6.1
	Upper Noyo River	67	70	71	71	75	74	74	8.4	7.4	7.4	7.4	6.1	6.6	6.6
Big River	East Branch North Fork Big River	53	55	61	53	55	55	63	11.8	11.5	10.0	11.8	11.5	11.3	9.4
	Lower North Fork Big River	58	60	60	61	63	65	69	10.5	10.0	10.0	10.0	9.2	8.9	7.9
	Martin Creek	59	67	68	70	72	74	73	10.5	8.4	7.9	7.6	6.9	6.4	6.6
	Mettick Creek	64	48	55	64	68	68	69	9.2	13.4	11.3	8.9	7.9	8.1	7.6
	Russell Brook	69	61	62	65	67	70	70	7.9	10.0	9.4	8.9	8.1	7.6	7.4
	South Daugherty Creek	61	53	56	62	66	70	70	9.7	12.1	11.0	9.4	8.4	7.6	7.6
	Two Log Creek	58	57	58	65	67	72	73	10.5	10.7	10.5	8.7	8.4	6.9	6.9
Garcia River	North Fork Garcia River	61	63	66	69	67	68	73	9.7	9.4	8.4	7.9	8.1	8.1	6.6
	Rolling Brook	68	68	68	69	70	69	72	8.1	8.1	7.9	7.6	7.6	7.6	6.9
	South Fork Garcia River	65	68	68	68	70	74	75	8.7	8.1	8.1	7.9	7.4	6.6	6.4
Navarro East	Dutch Henry Creek	60	58	61	64	64	70	69	10.0	10.5	9.7	8.9	9.2	7.6	7.6
	John Smith Creek	64	60	61	62	65	68	72	9.2	10.2	9.7	9.4	8.9	8.1	7.1
	Little North Fork Navarro River	57	54	57	62	65	69	71	11.0	11.8	11.0	9.4	8.7	7.6	7.1
	Lower South Branch Navarro R.	67	59	59	58	66	68	70	8.1	10.5	10.2	10.7	8.4	8.1	7.6
	Middle South Branch Navarro R.	59	55	55	55	60	60	63	10.5	11.5	11.5	11.3	10.2	10.0	9.4
	North Fork Indian Creek	65	64	67	66	67	73	71	8.9	8.9	8.4	8.4	8.1	6.6	7.1
	Upper South Branch Navarro River	61	58	58	67	67	68	68	9.7	10.5	10.7	8.4	8.1	8.1	7.9
Navarro West	Flynn Creek	74	71	69	75	78	73	75	6.6	7.4	7.9	6.4	5.4	6.6	6.4
	Hendy Woods	68	67	65	72	73	74	75	8.1	8.1	8.7	7.1	6.6	6.4	6.1
	Lower Navarro River	73	66	63	60	65	65	65	6.9	8.4	9.2	10.0	8.9	8.7	8.9
	Middle Navarro River	67	65	63	72	75	73	74	8.1	8.9	9.2	6.9	6.1	6.9	6.6
	North Fork Navarro River	74	70	70	77	80	76	76	6.4	7.4	7.4	5.9	5.1	5.9	5.9

[33] Versus watershed conditions of dense second-growth forest

Canopy Closure and Estimated Percent Increase of the Peak Flow

Inventory Block	CalWater Planning Watershed	Average Percent Canopy Closure by Time Period							Percent Increase in Peak flow 2 Year Return Interval						
		2002	2010	2020	2030	2040	2050	2060	2002	2010	2020	2030	2040	2050	2060
	Ray Gulch	63	65	66	74	75	75	75	9.4	8.9	8.7	6.4	6.4	6.4	6.4
	Upper Navarro River	68	63	69	72	75	74	70	8.1	9.2	7.6	6.9	6.4	6.4	7.4
Noyo River	Hayworth Creek	66	68	75	77	77	77	77	8.7	7.9	6.1	5.6	5.6	5.9	5.6
	McMullen Creek	69	73	73	68	76	68	70	7.6	6.9	6.9	7.9	6.1	7.9	7.4
	Middle Fork Noyo River	49	69	75	79	79	79	79	13.1	7.9	6.1	5.4	5.4	5.1	5.1
	North Fork Noyo River	64	65	65	74	76	73	76	9.2	8.7	8.7	6.4	6.1	6.9	6.1
	Olds Creek	66	63	65	66	70	69	70	8.7	9.2	8.9	8.4	7.6	7.6	7.4
	Redwood Creek	56	65	66	69	69	74	76	11.3	8.9	8.7	7.9	7.9	6.6	5.9
Rockport	Cottaneva Creek	73	69	71	75	75	71	72	6.6	7.6	7.1	6.4	6.4	7.1	7.1
	Hardy Creek	58	68	78	79	78	76	77	10.7	7.9	5.6	5.4	5.4	5.9	5.9
	Howard Creek	66	70	73	76	75	78	76	8.7	7.6	6.6	6.1	6.1	5.4	6.1
	Jack of Hearts Creek	67	67	69	73	74	78	75	8.1	8.1	7.6	6.6	6.4	5.6	6.1
	Juan Creek	65	67	77	78	75	74	76	8.7	8.1	5.6	5.4	6.1	6.4	5.9
	Lower Hollow Tree Creek	66	67	71	74	74	73	75	8.7	8.1	7.4	6.4	6.6	6.6	6.1
	Middle Hollow Tree Creek	63	65	69	74	74	73	77	9.2	8.9	7.6	6.6	6.4	6.9	5.9
	Upper Hollow Tree Creek	58	58	59	72	72	77	79	10.7	10.7	10.2	6.9	6.9	5.6	5.4
South Coast	Lower Alder Creek	72	73	71	73	77	77	77	7.1	6.9	7.1	6.6	5.9	5.9	5.9
	Lower Elk Creek	74	75	76	73	74	71	74	6.4	6.4	5.9	6.9	6.4	7.1	6.4
	Lower Greenwood Creek	76	73	73	73	74	74	74	5.9	6.6	6.6	6.6	6.4	6.4	6.4
	Mallo Pass Creek	65	65	73	70	71	72	73	8.9	8.7	6.9	7.6	7.1	7.1	6.9
	Upper Elk Creek	67	65	67	70	73	71	73	8.1	8.7	8.1	7.4	6.6	7.4	6.9
	Upper Greenwood Creek	68	61	67	72	75	74	76	8.1	9.7	8.1	6.9	6.4	6.4	6.1
Ukiah	Upper Ackerman	60	52	54	58	61	63	61	10.2	12.1	11.5	10.5	9.7	9.2	9.7
Median Value		***65***	***65***	***67***	***70***	***72***	***73***	***73***	***8.7***	***8.9***	***8.1***	***7.4***	***6.9***	***6.9***	***6.6***

It is estimated that, for average wetness conditions observed for a 2-year event (wetness index value of 304), increases in current peak flow range from 5.9% to 14.5%. The median observation is 8.7% greater than peak flows expected from a fully forested, second growth watershed condition. By 2060, the cumulative effect of forest harvest on increases in peak flows will be lowered to a range of 5.1-9.7%, with a median observation of 6.8%.

Estimates of increase in peak flow, presented in Table 8-27, are based on an average wetness index. As we stated earlier, the peak flow equation is very sensitive to the wetness index. When conditions in a watershed are very dry, then peak flow increases can be much higher than shown. When watershed conditions are very wet, peak flow increases will be lower.

Table 8-27 Estimates of Increase in the Peak Flow

		CalWater Planning Watersheds					
		Conditions in 2009			Conditions in 2060		
Antecedent Wetness	Index Value (w)	Minimum Peak Flow Increase (%)	Maximum Peak Flow Increase (%)	Median Peak Flow Increase (%)	Minimum Peak Flow Increase (%)	Maximum Peak Flow Increase (%)	Median Peak Flow Increase (%)
Dry	50	17.2	41	***26***	14.9	29.4	***19.9***
Average Wetness	304	5.9	14.5	***8.7***	5.1	9.7	***6.8***
Wettest	600	1.9	4.5	***2.8***	1.7	3.1	***2.2***

Peak flows greater than or equal to a 2-year return interval for gauged watersheds (or historically gauged rivers) in the plan area (Noyo River, Navarro River, Albion River, and Big River) have occurred predominately in January and February. There have been few 2-year-or-greater events in late December and only one in March. Though extended dry periods can occur at that time of year, it is reasonable to assume that peak flows greater than or equal to a 2-year return interval occur in predominately wet antecedent conditions. The use of peak flow increase derived from average wetness (w=304) is the best estimate of recurring conditions for a 2-year event.

8.4.3.2 Effect of increased peak flows on aquatic habitat and organisms

At the North Fork Caspar Creek weir (drainage area approximately 1200 ac), where the peak flow equation that we use was developed, the 2-year peak flow was increased by 9% (Ziemer 1998). This increase followed approximately 50% removal of canopy across the watershed, due to clear-cutting. In North Fork Caspar Creek, Lisle and Napolitano (1998) were not able to distinguish a substantial channel modification from this magnitude of peak flow increase. The level of peak flow increase in North Fork Caspar Creek is comparable to what MRC is currently predicting for our land. Over time MRC will not have any watersheds with 50% of the canopy removed; currently there is only one. In most cases, the percentage of canopy will be much higher because of MRC uneven-aged management. Given that the amount of canopy removed will decrease over time, we do not anticipate substantial scour or channel modification. De Vries (2000) found that small changes in peak flow from logging, like those predicted here, would have minimal effect on anadromous salmonid survival. Depth of streambed scour is dominated by streambed sediment supply and distribution, not by flow rate. This is important because channel modification from increased peak flows could negatively influence aquatic habitat.

As stated previously, the largest increase of peak flows are from first stream flow events in the fall, when antecedent wetness conditions in a watershed are low. Though these events do not have a high probability of being large events (i.e., 1-year recurrence intervals or greater) that could influence channels or modify habitats, they might create a direct impact on young-of-the-year salmonids. It has been hypothesized that increased peak flow from forest harvest may result in displacement of young-of-the-year salmonids downstream. Providing good over-wintering habitat in streams for refuge from high flows could likely offset the effect of increased peak flows. LWD is a significant habitat component in forested streams for improving over-wintering habitat. Conservation measures outlined in our HCP/NCCP will increase LWD recruitment to stream channels. Small increases in peak flow are not expected to provide enough additional stream power to create increased transport of LWD. Increases in LWD and subsequent improvement in over-wintering habitat should minimize downstream displacement of young-of-the-year salmonids. Displacement of amphibians covered in our HCP/NCCP is unlikely. By fall, most amphibians will be in their adult form—able to leave a stream to evade high stream flow events. Finally, channel roughness, increased by LWD, will slow water velocities and prevent barriers to upstream anadromous salmonid migration.

Localized increases in stream flow, due to road or other compacted surfaces, could result in increased sediment yield from streambed scour and bank erosion; down-cutting of stream channels and degradation of channel banks; increased turbidity due to increased sediment inputs; and formation of gullies.

In steep headwater streams, increased channel erosion or streambed scour could result in reduction of pool habitat for amphibians which are breeding and rearing; increased turbidity; and less substrate for amphibians to attach to or burrow in.

MRC considers conservation measures to reduce concentrated run-off from roads or other compacted surfaces that creates gullies or localized channel and bank erosion an important issue and addresses this in our road design standards (see Appendix E, *Road, Landing, and Skid Trail Standards*).

8.4.3.3 Water yield and low flow after forest canopy removal

Water yield typically increases following forest harvest. Lewis et al. (2000) reported increases in storm run-off as much as 400%; most increases were less than 100%, including 50% clear-cut harvest in the North Fork Caspar Creek. The increase in water yield can be short-lived, with effects diminishing within a few years due to re-growth of vegetation following harvest (Keppeler and Ziemer 1990). While Keppeler and Ziemer do not specifically attribute the reduced water yield to increases in conifer growth, ample evidence exists to suggest that, in a well-stocked redwood forest, such a reduction can indeed be attributed to conifers.

Low flows in summer tend to increase after forest harvest but were found to diminish 5 years after selective harvest in South Fork Caspar Creek (Keppeler and Ziemer 1990, Keppeler 1998). This was due to new water demands from the regenerated forest after harvest (Keppeler and Ziemer 1990). In North Fork Caspar Creek 6-8 years after a 50% clear-cut harvest, no reduction in summer low flow had been observed (Keppeler 1998). Data suggests that water yield will persist longer after clearcutting than when a similar timber volume is removed from a watershed with selective cutting. These differences in water yield recovery are probably related to changes in rainfall interception and evapotranspiration.

At Caspar Creek, enhanced low flows in summer increased aquatic habitat in stream channels. In the Caspar Creek study, higher levels of low flow increased habitat volumes and lengthened the flowing channel network along logged reaches (Keppeler 1998). However, an increase in biomass of invertebrates was not observed (Nakamoto 1998). The majority of MRC harvest will use selective harvest techniques. We expect this to minimize low-flow impacts.

8.4.3.4 Fog and hydrologic change

Fog is a significant hydrologic input to coastal watersheds of the Pacific Northwest. Fog precipitation or fog drip occurs when fog droplets encounter an obstruction, coalesce, and fall to the ground. Forest canopy is particularly efficient at intercepting water droplets and inducing fog drip. In a study site at the mouth of the Klamath River, Dawson (1996) determined that 8-34% of water used by coastal redwood trees and 6-100% of water used by under-story vegetation originated as fog drip. In Point Reyes, Ingraham (1995, as cited in Keppeler 1998) found the isotopic composition of groundwater reflected contribution of fog water.

That part of the plan area directly adjacent to the coast receives fog precipitation for 30-50% of the days in June, July, and August (Goodridge 1978). However, just a few miles inland, there is fog precipitation for 10-35% of the days for the same time period (Keppeler 1998). Most inland areas of the plan area receive little fog. The coast range ridges and mountains provide an effective barrier to inland penetration of marine fog layers.

At Caspar Creek, observation in upslope swales (i.e., soil pipe studies) and stream flow observations both have indicated increased water yield after logging. This suggests that loss of fog drip did not play a significant role in hydrologic changes following forest harvest (Keppeler 1998). In addition, loss of evapotranspiration from forest harvest may be a more significant variable to changes in watershed hydrology than fog drip. If fog drip was an important component of hydrologic change at Caspar Creek, then soil moisture and stream flow should have decreased after logging. However, it increased, suggesting little effect (Keppeler 1998).

8.4.3.5 Water drafting

Drafting of water from watercourses, ponds, and springs is necessary for the maintenance of the road network during the dry summer season. Inadequate surface wetness combined with heavy traffic can deteriorate the running surface of the road to a powdery fluff which fall precipitation can easily transport. Roads with heavy traffic may require multiple applications of water per day in order to properly maintain the road surface. This necessitates removing thousands of gallons of water from a drafting site on a daily basis. Road surface preparations, such as lignin, may reduce the amount of water needed for maintenance, but applications of this product can be cost prohibitive. Drafting from watercourses may also impact biological resources within close proximity to the drafting site by

- Reducing the water of rifle crests and side-channel pools, thereby limiting the movement of aquatic wildlife.
- Increasing predation in pools as a result of decreased pool volume.
- Altering stream temperature by decreasing water volumes.

In order to minimize such impacts, MRC will adhere to guidelines on water drafting within MATO. Furthermore, MRC will submit annual compliance monitoring reports on water drafting activities. An example of this annual report is in Appendix D, *HCP/NCCP Report Timelines and Samples* (section D.2.11).